POWER

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To Celebrate Dad's Raise at the Dower-House

Automatic Oil-Burning Plant in California Sugar Refinery

Particulars of the Equipment and Details of P. rformance of the Most Up-to-date Oil-Burning Steam-Power Plant—Steam Coils to Smother Fire—Boiler Room Has Complete Gage and Control Board

BY CLAUDE C. BROWN
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THE California & Hawaiian Sugar Refining Co., whose 2,000-ton capacity cane-sugar refinery is located at Crockett, Cal., has the distinction of possessing one of the most modern and up-to-date automatically controlled oil-burning boiler plants on the Pacific Coast. The new boiler room is shown in Fig. 1 and the turbine room in Fig. 2.

This plant, which was installed by Charles C. Moore & Co., engineers, San Francisco, Cal., consists of ten 600-hp. water-tube boilers equipped with economizers, together with all the automatic control apparatus necessary for the economical and efficient burning of oil.

The boiler plant is composed of the "New House," which contains the ten 600-hp. boilers, and the "Old House," which contains four 275-hp. water-tube boilers, four 250-hp. water-tube and fourteen 175-hp. return-tubular boilers.

Two separate steam-pressure systems are maintained at present; in the "New House" steam is generated at 150 lb. for operating three 1,500-kw. non-condensing horizontal turbo-generators. The surplus steam from this high-pressure header is stepped down through an automatically regulated butterfly valve, and delivered through a crossover connection, Fig. 3, fully guarded with safety valves, to the 100-lb. header of the old house. The steam from this header, after being reduced to 55 lb. pressure, is used almost entirely for the concentration of sugar solutions to the crystalline stage, in 14-ft. diameter vacuum pans.

The turbines are non-condensing and exhaust into an exhaust steam system, the pressure of which is maintained at about 10 lb. The steam from this exhaust system is also used for the concentration of sugar solutions to the crystalline stage. In addition it is used for the heating of various liquors, syrups, etc., and supplies the necessary heat to operate a quintuple evaporator of approximately 15,000 sq.ft. of heating surface. It also heats over one million gallons of water daily for refinery use.

The pressure on the exhaust-steam system is maintained fairly uniform at 10 lb. per sq.in. by one of two 6-in. reducing valves which operate between the 150-lb. live-steam header and the 10-lb. exhaust-steam header. This valve opens when the exhaust pressure drops to 5 lb. and closes when this pressure reaches 10 lb. If the exhaust pressure goes up to 15 lb., a multiport safety exhaust valve permits the excess exhaust steam to blow to the atmosphere.

The fuel oil used in this plant is a California product of about 17 deg. Bé. gravity, and contains approximately

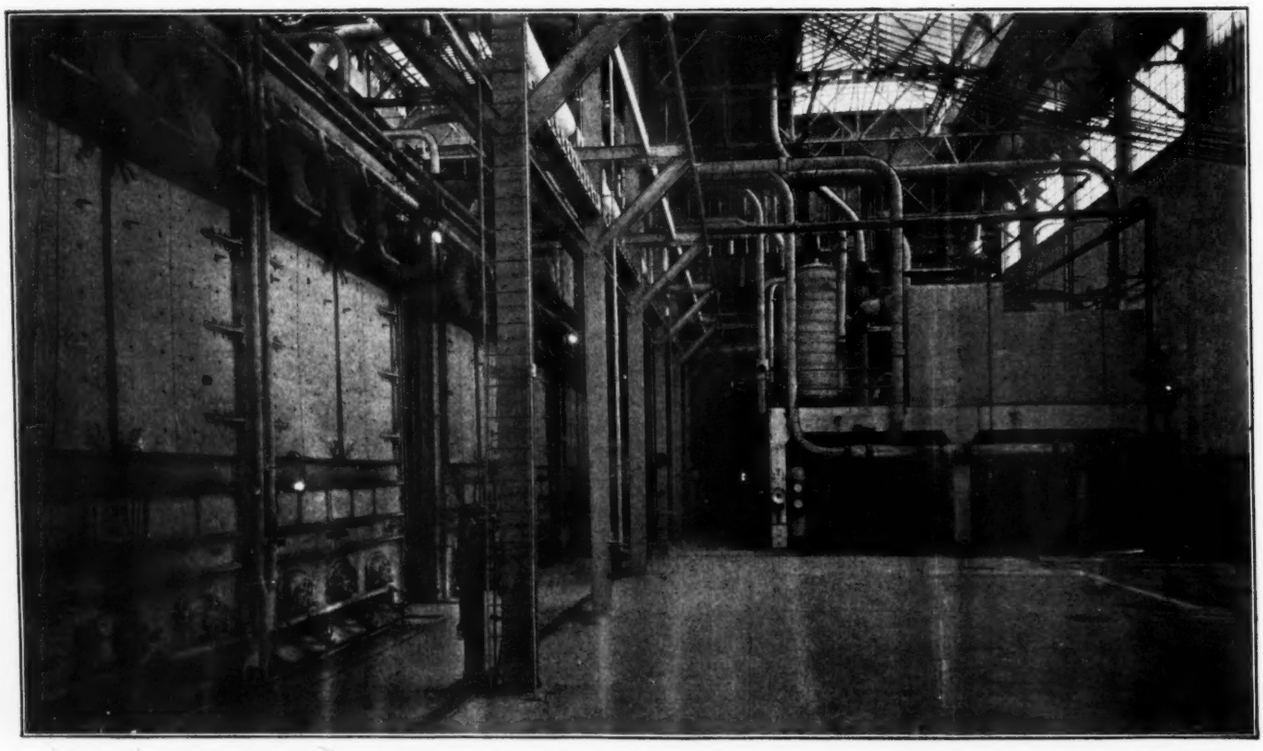

FIG. 1. BOILER ROOM, SHOWING GENERAL CONSTRUCTION, BOILERS AND FEED-WATER HEATER

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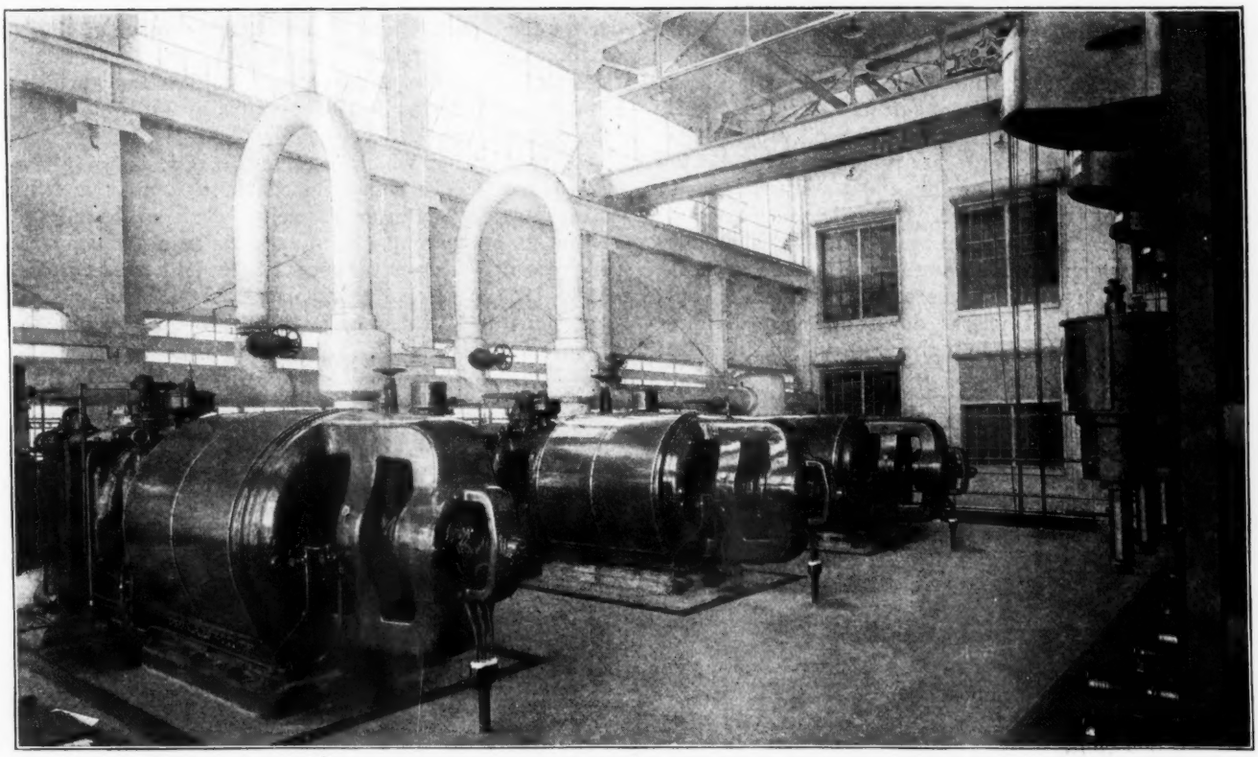


FIG. 2. VIEW OF THE TURBINE ROOM, CALIFORNIA & HAWAIIAN SUGAR REFINING CO.

18,750 B.t.u. per lb. It is brought to the plant in barges and pumped from the barges into two steel storage tanks of 25,500 bbl. and 3,780 bbl. capacity respectively. From these tanks it is pumped to four auxiliary underground concrete storage tanks adjacent to the boiler house. Two of these are used for furnishing fuel oil to the plant, while the others are being filled for stand-by storage. All tanks are equipped with steam smothering coils for use in case of fire.

The method of measuring the amount of oil drawn and consumed is accurate. Each tank is carefully calibrated for each quarter of an inch in depth and these figures are entered on a blueprinted table. At the end of each eight-hour shift, and also whenever the tanks in use are changed, careful soundings of the oil depth are taken by means of marked steel rods. These rods are counterbalanced by means of weights suspended on chains which pass over pulleys, so that their use requires little effort on the part of the operator.

Accurate temperature readings are taken at two-hour intervals by means of angle thermometers, and in addition to this a continuous recording thermometer is installed on the oil intake to the boiler-room oil pumps. At the end of each shift the average temperature of the oil is obtained and all readings corrected to a 60 deg. F. basis.

From the auxiliary tanks the oil is drawn through strainers to two duplex horizontal steam pumps, size 9 x 8 x 10 in., of 80 gal. per min. capacity each; from here it is delivered to two special coil oil heaters each having an internal heating surface of 600 sq.ft.

Each heater consists of twelve sections, each section containing a coil of 1-in. extra-strong wrought-iron pipe, from which the oil circulates from a 4-in. inlet and a 4-in. outlet header. Each coil is designed for a pressure of 150 lb. per sq.in.

Within the section castings and around the coils steam is circulated at exhaust pressure, 5 to 15 lb. The amount of steam admitted to these heaters is varied to maintain the outlet oil at a temperature of 180 deg. F., this temperature having been found to give the best results for combustion purposes.

From one of these heaters the oil is led directly to an oil header above the 22 boilers in the Old House, and thence through drop lines to the oil burners of each boiler. From the other heater the oil is led through an automatically controlled butterfly valve, and from thence to the oil headers over the ten boilers in the New House.

The pressure of the oil at the burners is automatically controlled by a regulating system described in detail later. This pressure is varied between 10 and 30 lb., according to the steam demands.

The oil burners used on all boilers are an outside-mixing, steam-atomizing type. They are "rear shot"; that is, they extend the full length of the furnace, underneath the furnace floor, and rise into a small housing at the bridge wall; the burner head faces forward toward the boiler front, and the flame travels from the bridge wall forward. At the inlet to each burner is a small removable strainer that catches any grit and dirt that comes through the heaters.

In the refining of sugar much heating and boiling is done by means of steam coils immersed in the product to be boiled or heated. The return drips from these coils are led back to the boiler room by gravity and into one of two open feed-water heaters, each of a capacity of 250,000 lb. of water per hour. These return drips constitute about one-half of the feed water evaporated. The remaining half is made up of treated river water, which is admitted to the heater at the steam-inlet end. From the heaters, which are placed

on a raised concrete platform, the feed water drops straight down to one of two turbine feed pumps on the boiler-room floor underneath the heater platform.

The makeup water, which comes from the Sacramento River, is pumped to a softener, located outside the boiler room and over the auxiliary oil tanks.

This softener is a cold-process type apparatus, having a capacity of 27,000 gal. per. hr. and a storage capacity of 17,000 gal. of treated water. It consists of a redwood tank, 30 ft. 9 in. in diameter by 19 ft. 4 in. high, into one side of which is led the water, together with its lime and soda treatment, where it is stirred or agitated. From here it passes down under a dividing partition and comes up through an excelsior filter bed horizontal pumps that feed the Old House. The turbine-driven feed pumps are of the turbine type, of 1,000 g.p.m. capacity, against 462 ft. head, at 1,800 r.p.m. Each is driven by a horizontal, single-stage turbine, 1,800 r.p.m., with a throttle pressure of 140 lb. and an exhaust pressure of 15 lb.

The feed water, which is at an average temperature of 170 deg. F., is then pumped through a 10 x 4-in. venturi meter having a capacity of from 55,600 to 722,000 lb. of water per hour, and its rate and amount are recorded. From thence it goes, at approximately 190 lb. to five economizers, each consisting of 32 sections of 10 tubes each, the tubes being 4⅝ in. in external diameter by 12 ft. long. The capacity of each

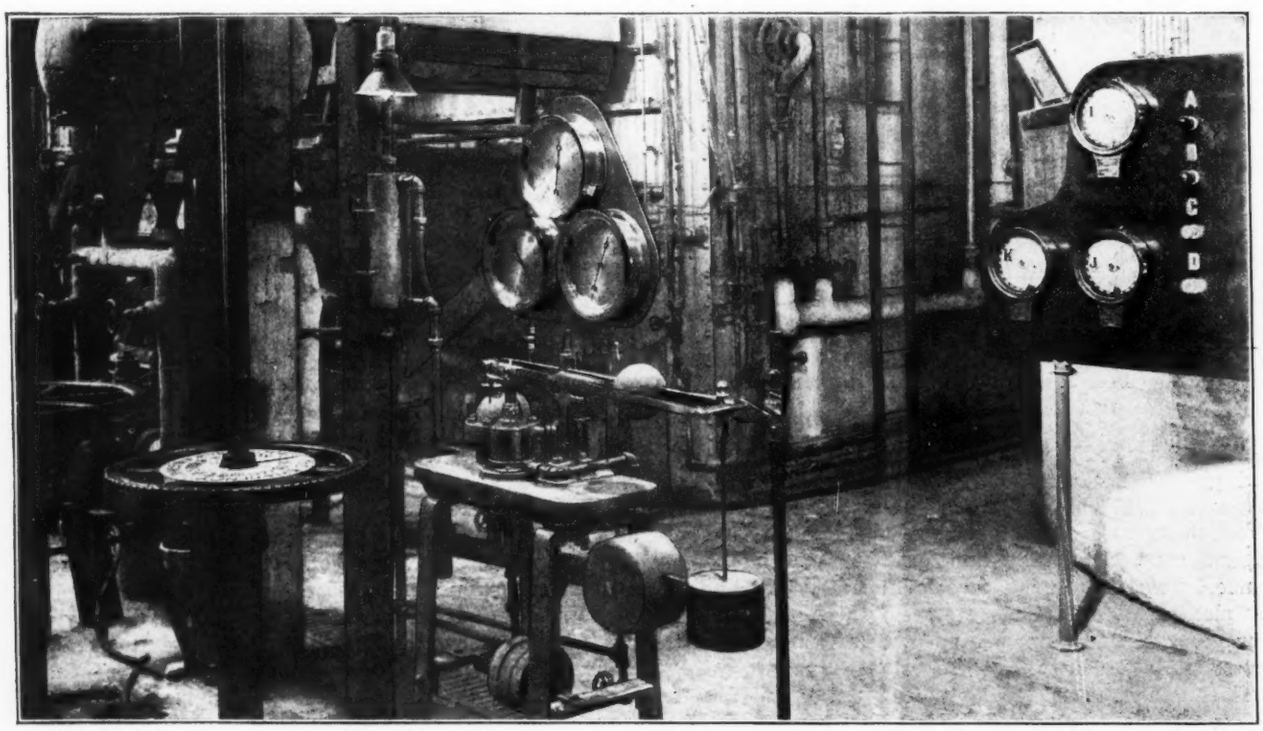


FIG. 3. CROSSOVER REGULATOR, SHOWING HYDRAULIC CYLINDER WHICH OPERATES THE BUTTERFLY VALVE

to the outlet on the other side. From this point the treated water drops by gravity to a cistern underneath the boiler house. From the cistern it is picked up by one of two motor-driven centrifugal service pumps each capable of pumping 1,000 gal. per min. against a head of 55 ft., and delivered to the feed-water heaters through float-operated valves that maintain a depth of three feet in the heaters.

To prevent the possibility of the turbine-driven feed pumps running away after draining the heater dry, with the power off the motor-driven centrifugal service pumps, there is installed an emergency duplex steam pump, size 7½ x 8½ x 10 in., with a capacity of 500 gal. per min. Should the water level in the heaters fall to 24 in. from the bottom, a float-actuated valve opens, releases the pressure on the discharge side of this pump, which in turn operates a governor, thereby admitting steam and delivering 500 gal. per min. from the cistern to the heaters.

From the bottom of the heaters a manifold delivers the water to one of two turbine feed pumps which feed the boilers of the New House, and three reciprocating

economizer is 19,840 lb. of water, and each has a heating surface of 4,080 sq.ft.

From the economizers the feed water passes to headers that are located over the tops of the boilers, and the feed to each boiler is taken care of automatically by a regulator.

The New House consists of ten 600-hp. Babcock & Wilcox vertical header boilers, each equipped with a patented oil-burning furnace consisting of a checker brick floor with ashpits divided into three equal aisles, one aisle under each of the three burners.

Each boiler is steel incased, the steel casing covering 4 in. of 85 per cent asbestos magnesia insulation. The boilers are set in batteries of two each, the front center column being eliminated, the weight being taken at this point by an extra-heavy cross-beam which extends clear across the fronts of the two boilers. The boiler fronts are held in place by means of four stay rods which extend from the front false column, through the center wall, to the rear center column. These rods are 1¼ in. diameter and each is inclosed in a 2-in. pipe. Each boiler consists of three 42-in. drums, 20 ft.

5½ in. long and 21 sections of tubes, 14 tubes high, each tube being 4 in. in diameter by 18 ft. long. The stop valves are 8-in. automatic type, and all joints in risers and pipe lines are of the Van Stone type. On each boiler is a complete installation of soot blowers and a differential draft gage. In the main riser from each boiler there are ¾-in. taps and valves that are used for the purpose of making moisture determinations with the calorimeter.

On one boiler there has been installed a steam-flow meter, recording draft gage and recording flue-gas thermometer. In addition there are three CO_2 machines each fitted with recorders and indicators.

Each of the five machines takes care of two boilers. Fig. 4 shows the boiler-house gage board.

An automatic regulator controls the fuel-oil pressure, the steam-to-burner pressure and the damper opening, that as a rule the dampers are left wide open, it can be readily appreciated that an efficient, uniform rate of firing by hand methods is well-nigh unattainable, if not impossible.

The automatic regulating system in this plant controls the supply of oil to all burners, the supply of atomizing steam (which is reduced from boiler pressure) for ten boilers, and one damper regulator controls the damper opening on six and another on the remaining four boilers, all from a single central point. All burners are operated with burner valves wide open, the size of fire being automatically controlled by the regulation of oil pressure. This applies also to the atomizing steam valves. All the dampers of the six boilers which are controlled by one of the damper regulators are connected to a common rocker shaft and move simultaneously. Similarly, those of the four

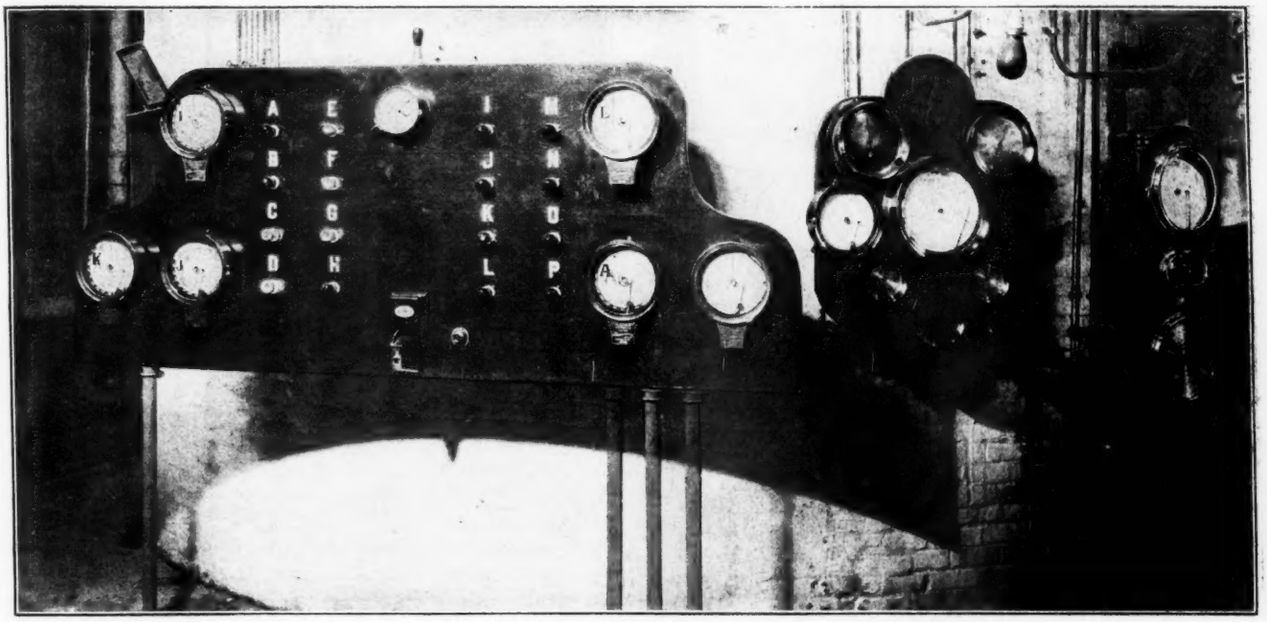


FIG. 4. THE BOILER-HOUSE GAGE BOARD

varying each in accordance with the load demand. This regulating system consists of: Oil-to-burner pressure regulator, Fig. 5; steam-to-burner pressure regulator, Fig. 6; damper regulator; water pump and necessary motors; hydraulic cylinder, tank, piping drains, etc.

The principle upon which this regulating system works is the varying of the oil pressure inversely with the steam pressure on the main header, and in turn the varying of the reduced steam pressure to burners and damper opening more nearly directly with the oil pressure.

A description of the operation of this automatically operated boiler plant follows:

In so-called hand-fired plants it is generally the custom to maintain a constant oil pressure at the fuel-oil pump and to regulate the generation of steam in individual boilers by throttling the burner valve of each boiler, thus increasing or decreasing the size of the fires under each boiler in accordance with the judgment of the operator. When the fact is taken into consideration that almost always the amount of atomizing steam, which is generally at full boiler pressure, is left unchanged and remains a maximum for all loads, and also boilers act likewise and are controlled by the other damper regulator.

Any variation in steam pressure of the main header due to a variation in the load demand is the primary means of control of a steam governor which varies the oil pressure in the oil headers. When the main steam pressure drops, owing to increased demand for steam, the regulator increases the oil pressure in the oil headers, which in turn increases the size of the fires and consequently the rate of evaporation. An increase in steam pressure in the main header works just opposite and tends to reduce the oil pressure. In this way a state of equilibrium is reached for any given steam-demand rate.

In the steam-to-burner regulator the actuating elements are opposing steam and oil diaphragms with areas and leverages conforming to a ratio of approximately 4 to 1 between atomizing steam and oil pressure. Any increase in oil pressure causes an increase in the pressure of atomizing steam in accordance with this ratio. This is accomplished by means of the action of a butterfly valve in the steam-to-burner main, which is actuated by the water motor of the regulator. Thus

the steam-to-burner pressure is regulated by the oil pressure.

In the damper controller also the oil pressure is the controlling factor. A diaphragm is actuated by the pressure of the oil in the fuel-oil header, and the movement of the diaphragm is opposed by a lever connected to a coil spring, which is adjustable along the lever for the purpose of obtaining the required range of oil pressure. A double-ported valve connected to the controller admits water from the pressure-supply system, either to the top or to the bottom of a hydraulic cylinder which actuates the aforementioned rocker shaft, to which the dampers of all the six boilers in one case and four in the other are connected.

The action of these regulators is entirely automatic. To cut out any of them, it is necessary only to close the

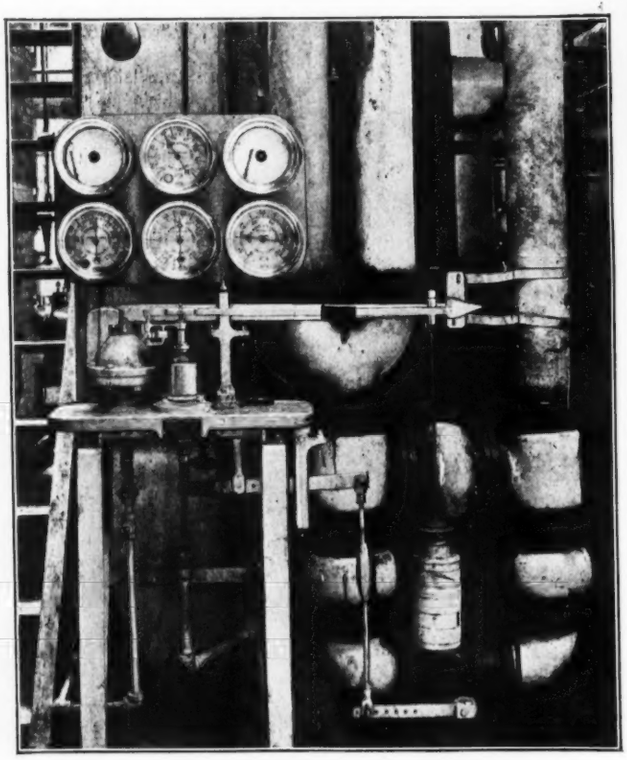


FIG. 5. FUEL-OIL REGULATOR

valve between the oil header and the oil-to-burner regulator, bypass the steam-to-burner regulator or cut off the pressure-supply water to the damper-controller hydraulic cylinder, opening both drain valves, which will allow the dampers to be thrown wide open by their counterweights and regulated by hand.

When the automatic control has been once set, little trouble is experienced with it. The accompanying log sheet, Fig. 7, for May 12, 1920, will show the results obtained with the automatic control system.

After all boilers have been put on and the fires started, it is the practice at this plant to equalize all the fires and make refined settings of both steam-to-burner and damper controllers. When the respective dampers are set, the fires are equalized by slightly opening or closing all the burner valves, thus setting the valves so that they pass just enough oil for complete combustion, which is indicated by a slight smoky haze as seen through the side peepholes of the boiler. Similarly, the steam-to-burner supply is adjusted by slightly opening or closing all the supply valves on the burners. On sudden changes of load of large proportions

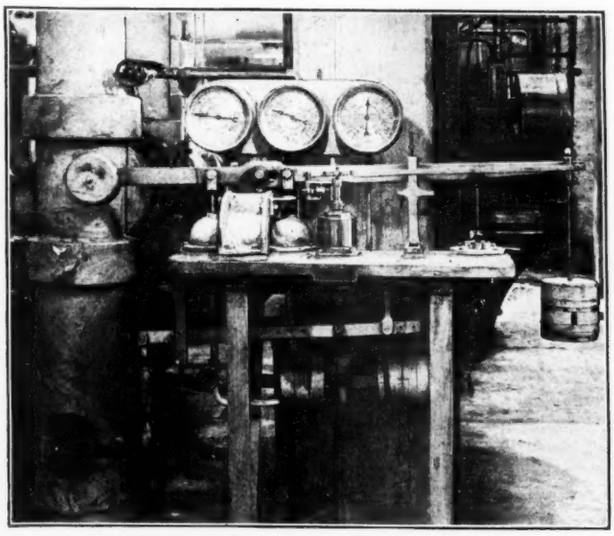


FIG. 6. THE STEAM-TO-THE-BURNER REGULATOR

the regulators all promptly act together. There is, however, one point to be noticed in connection with this automatic control; namely, that after a certain set of

California and Hawaiian Sugar Refining Company
CROCKETT CALIFORNIA

BOILER ROOM PERFORMANCE FOR 24 HOURS ENDING 8 AM 5-13-20 192

A	Oil used	Pounds per hour	16230	See "Oil Fuel" Page 34
B	Water to boilers	" " "	246800	
C	Water blown off	" " "	3080	
D	Water evaporated	" " "	243720	D = B-C
E	Temperature of feed water entering boilers	Deg. Fahr	219	
F	Total heat per pound of steam at pounds Gage Press	B. t. u.	1195	See "Steam" Page 122
G	Total heat per pound of feed water entering boilers	"	187.1	See "Steam" Page 120
H	Net heat added per pound of steam	"	1007.9	H = F-G
J	Total heat per pound of water blown off	"	338.2	See "Steam" Page 123
K	Net heat added per pound of water blown off	"	151.1	K = J-G
L	Total equivalent evaporation from and at 212 °F	Lbs.	253000	$L=\frac{D\times H\times C\times K}{970.4}$
M	Equivalent evaporation from and at 212 °F per pound of fuel oil		15.6	$M=\frac{L}{A}$
N	B. t. u. per pound of fuel oil		18761	
P	Steam consumed by burners	Lbs. per hour	3368	
Q	Gross efficiency (boilers only)		80.7	$Q=\frac{D\times H\times C\times K}{A\times N}\times 100$
R	Factor of evaporation		1.038	R = H-970.4
S	Net efficiency (boilers only, deducting steam to burners)		79.6	$S=\frac{D\times H\times C\times K-P\times H}{A\times N}\times 100$
T	% steam used by burners		1.38	$T=\frac{P\times H\times C\times K}{D\times H\times C\times K}\times 100$
U	Total B. H. P. developed		734.0	$U=\frac{L}{34.5}$
V	Number of boilers in service		9	
W	% rating of boilers		136	$W=\frac{U}{600\times V}\times 100$
X	Temperature of feed water leaving economizers	Deg. Fahr	219	
Y	Temperature of feed water entering economizers	"	170	
Z_1	Rise in temperature of feed water in economizers	"	49	
Z_2	Temperature of flue gases leaving boilers	"	540	
Z_3	Temperature of flue gases leaving economizers	"	350	
Z_4	Drop in temperature of flue gases through economizers	"	190	$Z_4=X-Y$
Z_5	CO (Averaged from recording charts)	%	13.5	$Z_5=Z_4-Z_3$

NOTES—In order to be able to compare the performance of the boilers from day to day, five barrels of oil should be deducted from the total amount of oil used during a day when a cold boiler has been fired up and put on the line. No deduction should be made when starting up a cold economizer
All values given above are the averages for the 24-hour period
For purposes of this log, assume dry steam leaving boilers.

Total amount of water fed to boilers per week
Amount of purified water fed to boilers per week
% purified water to total water fed to boilers per week

Power Engineer

FIG. 7. THE BOILER-HOUSE PERFORMANCE SHEET

conditions become established for a given load, such as rate of flow of chimney gases, temperature of gases, draft, etc., the regulator will respond to changes in load more quickly than the chimney. The result is

that momentary smoking is caused, the condition enduring for a brief period, which is known as the "lag."

While this system results in a large saving in manual labor, it does not dispense with any large number of firemen. We have at this plant a total of 32 boilers. The boiler-room crew consists of one fireman and two water tenders per shift and the repair gang of nine men, all under the supervision of a boiler-house foreman. The saving as obtained with the various aforementioned devices comes in the increased economy as obtained with automatic regulation over hand regulation. With the automatic regulation the personal element is eliminated, and as long as the apparatus is kept in good order, more dependable economical and efficient operation is sure to result.

George M. Rolph is general manager, A. M. Dupern, plant manager, and L. L. Edmunds, chief engineer, for the California & Hawaiian Refining Co.

Some of the equipment in the power plant of the California & Hawaiian Sugar Refining Co.:

Consulting Engineers, Charles C. Moore Co.
Ten 600-hp. Babcock & Wilcox water-tube boilers, four 275-hp. Stirling boilers, fourteen 175-hp. return-tubular boilers.
One 1,500-kw. Curtis non-condensing turbine.
Automatic oil burning system, C. C. Moore Co., San Francisco.
Oil-burning furnaces, Peabody, "rear shot."
Fuel oil, 17 deg. Bé; 18,750 B.t.u. per lb.; Standard Oil Co.
Fuel-oil burners, Leahy, type D1.
Oil heaters, National Pipe Bending Co.
Feed-water regulators, Copes.
Feed-water heaters, open, Cochrane.
Water softener, cold process, Booth, type F-14.
Thermometers, Tycos.
Economizers, Green.
Soot Blowers, Diamond.
CO_2 recorders, Uehling.

Ammonia-Compressor Troubles

By J. C. MORAN

ONE of the two small vertical single-acting compressors in a cold-storage plant began to develop a slight knock one day, and this gradually got worse until about a week later it became so bad that it had to be attended to. The engineers hunted all over the machine for the cause of the trouble for several days without being able to discover it. When they were on the compressor deck it seemed that it was somewhere in the cylinder on one side, and when they were down below it appeared to be in the connecting rod or crank.

After taking up on the wedges and bearings all around until everything ran hot most of the time, one of the oilers suggested that it might be caused by too little clearance in the cylinder, and being unable to think of anything better to do and not wanting to shut the machine down for any length of time for close inspection, they decided to screw the piston rod into the crosshead a little more and thus increase the clearance. The rod was screwed in about $\frac{1}{16}$ inch for trial and the knock disappeared entirely. A few days later, however, it appeared again and was just as bad as ever. The rod was screwed in some more and again the racket stopped. This lasted only a day, when the knock came back again.

Valve-Seat Capscrew Caused Trouble

By this time the engineers realized that there must be something wrong inside the compressor. There was but one thing to do, and that was to shut down and open up the machine and examine the inside. When the cylinder head and the false head were removed and the piston and suction valve exposed, it was seen that one of the screws that hold the suction-valve cage in the piston had backed out and was striking the false head at the end of the stroke. The construction of the piston and the screw which caused the trouble is shown at *A* in Fig. 1. The screw was badly battered and the threads of both the hole and screw damaged so badly that it was impossible to put in a new one. The hole was reamed and tapped for a larger screw and a new screw inserted. After this had been done, no further trouble was experienced. As a precaution against future trouble of this nature the heads were removed once every two months and the suction valves and cages inspected for loose screws as well as other troubles that might have started.

One engineer having had trouble of this kind twice in succession during a hot spell one summer, stopped it by drilling a small hole about half an inch deep partly in the screw head and partly in the body of the valve cage. The hole was filled with babbitt. This served as a dowel pin and securely locked the screw in place. When he wanted to take the screw out all he had to do was to run the drill down into the hole, removing most of the babbitt; then the screw came out as easily as before.

Piece of Pipe Caught Under Valve

One night one of the engineers in the plant first mentioned heard a hard thump on one of the machines, and from then on there was a steady but light pound as it passed the center at the top. It was reported to the chief the next morning, and he decided that it must be caused by the piston rod backing out of the crosshead as he found that the locknut on the crosshead was loose. After the piston was screwed in a couple of turns, the knock disappeared and no more was heard of it.

Another trouble appeared, however. The machine did not run steadily, but made a jump at every revolution and, so it seemed, on the compression stroke of the cylinder on which the knock had existed before. At first the trouble was believed to be in the governor, but this was tinkered with for a couple of weeks without any sign of improvement.

At the same time the cylinder on this side ran very hot and it was also noticed that the suction-pressure and discharge-pressure gages on the machine jumped considerably. Furthermore, they had to run the compressor quite a little faster for about the same amount of work, so they finally came to the conclusion that they had better look inside.

When the head and false head were removed they could see nothing wrong and were just about to replace the heads when one of the men happened to put his hand on the suction valve. To his surprise it stopped solid while it was still $\frac{1}{16}$ in. open. This led to further investigation, and it was finally discovered that there was a short piece of $\frac{1}{4}$-in. pipe caught under the valve, as indicated by *B*, Fig. 1. It had been crushed flat. No one knows to this day where that piece of pipe came from or how it came to work its way into the cylinder. It was just another of those cases where the unexpected happens and in the most unheard of places.

By inspection of Fig. 1 it will be noticed that the spring *C* tends to hold the valve open instead of closed; in fact, when the machine is opened up, it will generally be found that the valve remains partly open. This is as it should be, the purpose of the spring being to practically balance the valve so that it will close more easily at the end of the suction stroke and open more lively at the beginning of the suction stroke. One man, in charge of his first plant, decided that this was all wrong and proceeded to fix it up to suit himself. First he cut off a few sections of the spring, which made it considerably shorter. He then drilled holes in the valve and also in the recess for the spring in the valve cage and rigged up some hooks so that when the whole rig

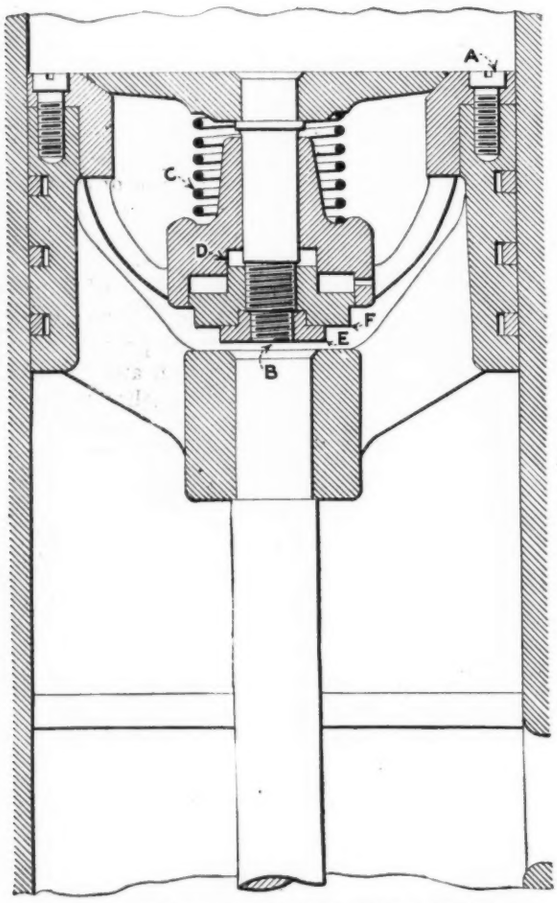


FIG. 1. DEFECTIVE VALVE-SEAT CAPSCREW

was in place the spring tended to pull the valve shut with considerable force.

The change did not seem to make much difference excepting that at times the valves had a tendency to slam at the end of the suction stroke. They also had to run the machine quite a bit faster because the restriction of the valve area by the tight spring holding the valve partly shut most of the time kept the cylinder from filling properly. One day there was solid thump in one cylinder and, while it slacked off a little, it did not stop. It continued so long that the engineers decided that they had better look into it, so it was pumped out and the heads removed.

It was then found that one of the hooks which had been inserted to hold the spring of the suction valve had come loose and got caught between the valve and seat, holding the valve open all the time, and as the clearance was pretty close there was nothing for it to do but bump up against the safety head at every revolution. The valve was so badly battered that a new one had to be ordered from the factory. One of the company's erecting engineers also came along to help put it in when it was delivered. When he found out what the engineer had done to the springs, he said a few things that would not look well in print. After explaining to the chief what the spring was for and how it worked, he ordered a new set of springs and put them in the way they were originally intended. When they started up the machine again, they were able to handle the load at considerably lower speed and it also ran quite a bit cooler.

Broken Valve Cage Puzzles Experts

In another plant one of the two machines of the same make suddenly began acting irregularly. On the crank-end stroke of the steam cylinder it would take a sudden jump and then slow down with a jerk as it neared the center, while the governor jumped up and down like a jack-in-the-box. All the governor experts in the neighborhood tried their hand at it without improving matters in the least, and finally a man from the factory was sent for.

He went over the machine from one end to the other, tinkered with the governor, reset the steam valves two different times, opened up the compressors and found everything in good order and finally gave up and went back to the factory.

In a few days another man was sent out and brought along an indicator. First, he indicated the steam cylinder. This was in pretty good shape and after a few small adjustments he next indicated the ammonia compressors.

After sizing up the action of the machine, he first tackled the one he suspected might be the cause of the trouble. The first card looked somewhat surprising and he tried another with the same result. According to the indicator this compressor was getting practically no gas, as there was a high vacuum in the cylinder during the entire suction stroke and on the compression stroke the pressure barely reached discharge pressure at the end of the stroke. Apparently the compressor was doing little or no work.

From all indications there was some restriction in the suction connections or the suction valve to this compressor. The head and the false head were removed, and the machine was turned over very slowly. Then a flange was removed in the suction connection to this cylinder in order to provide an easily watched source of supply.

The suction valve appeared to be stuck, as it barely moved at each suction stroke of the compressor. Generally, these valves jump wide open at the instant the piston reverses its travel and starts downward. The suction-valve cage was then removed by unscrewing all the screws *A*, Fig. 1, which hold it in position, and when it was removed from the machine the valve was found to be practically stuck shut. There was a slight movement, just about enough to lift the valve off the seat.

After fussing with it for an hour or more, trying to work it loose, the expert finally decided to take it apart and the jam nut *E* and the large nut *F* were removed. When the large nut was slipped off, a small piece of the valve cage dropped out. This was found to have been cracked out of the guide at *D*, the broken part

jamming into the space between the large nut and the guide. A new valve cage was ordered, and when this was installed all the trouble was over.

A 200-ton Ball compressor had been overhauled and put in service again a short time when it developed a sharp knock at irregular intervals. At times it was very light, and then again it sounded as if someone were pounding the cylinder as hard as he could with a heavy hammer.

At first it was thought that the trouble was in the valves, due to broken springs, which produce a somewhat similar racket, but this was found not to be the

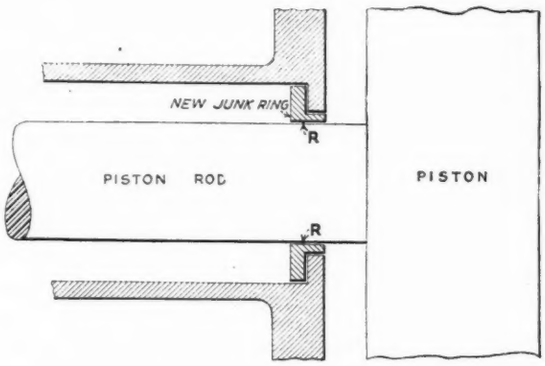


FIG. 2. REPAIR OF WORN STUFFING BOX

case. The piston was removed and every part was inspected for improper adjustment without finding anything wrong—everything was apparently in perfect order.

One of the oilers was a somewhat observing sort of a fellow, and he noticed that adjusting the stuffing box a little at a time had an effect on the racket. One day when it started again he began the same process and pretty soon the knock stopped altogether. After the stuffing box was loosened up again it was not long before the knock was as bad as ever.

Junk Ring in Stuffing Box Was the Cause of the Trouble

After thinking the matter over and trying it for himself, the engineer in charge came to the conclusion that the trouble was due to a junk ring that had been put in the bottom of the stuffing box to make up for the amount that the rod had been turned down during the overhauling. It must be remembered that the hole through the bottom of the stuffing box is just a snug fit on the rod when the rod is full size, and if the rod is turned down after it is worn, some provision must be made to make the bottom of the stuffing box a tight fit on the rod, otherwise the packing will all work out between the rod and the neck of the stuffing box. In most cases this is done by slipping a ring, generally termed a junk ring, into the bottom of the box, which is a snug fit on the rod. This is only a makeshift affair, but it generally serves the purpose, although it will frequently wear rapidly, as it did in this case, and then some other scheme must be worked out.

Fig. 2 shows how the engineer solved the problem. The neck of the stuffing box was bored out so that it was about half an inch larger in diameter than the full size of the rod. A ring was made of the cross-section shown, with the hole through it a snug fit on the rod and the ouside diameter of the projecting part a tight fit in the enlarged hole in the neck of the stuffing box. Whenever the rod was turned down, it was a simple matter to drive the old neck ring out and turn up another to fit the changed diameter of the rod. As the ring was a tight fit in the neck of the stuffing box, there was no possibility of its moving or knocking; it also reduced trouble with heating of the stuffing box and rod, occasioned by the changing pressure on the packing when the ring was shifting back and forth.

An Easy Check on Plant Economy

By E. H. Tenney

In St. Louis the Union Electric Light and Power Co. operates twenty-eight isolated plants, generating current to the limit of the heating requirements in those plants having generating equipment. As a guide to the operator on fuel requirements and as a check on the economy obtained, a chart on the order shown herewith is prepared for each building. To make up such a chart, a careful analysis is made of each building and its respective power plant. The type of construction, the proportion of glass area, the exposure, the amount of radiation, etc., are considered in computing the heat loss for the building. From such data the steam requirements for temperatures ranging from 10 deg. below zero to 70 deg. above are obtained. A careful inspection of the plant equipment and its physical condition determines the economy of operation and the evaporation to be expected from a certain quality of coal. The final analysis is thus brought down to pounds of coal per shift, and by plotting these data against outside temperature the chart is produced.

As an example, suppose the temperature during the night shift averages 20 deg., the coal requirements for

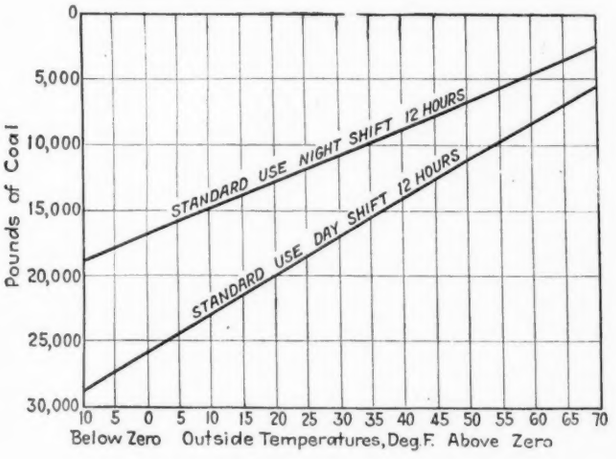


CHART OF COAL REQUIRED FOR TEMPERATURE CONDITIONS

the 12 hours will be 12,800 lb. If the temperature during the day averages 25 deg., the coal consumption should be 18,500 lb. A chart of this character is posted in the boiler room as a guide to the firemen, and of course charts for all buildings are retained in the supervising office to provide an easy check on plant records for determining whether the respective plant is operating at the economy expected or whether it requires the attention that would be needed if the coal consumption exceeded the chart figure.

Circuit Breakers—Principle of Operation

The Principle of Operation of a Modern Type of Circuit Breaker—Shunt-Trip Attachments, Underload Releases, Undervoltage Releases and Overvoltage Releases

By VICTOR H. TODD

THERE are a number of abnormal conditions that may occur in an electric circuit and against which protective measures must be taken to prevent damage to the various units such as motors, transformers, lines and generators. The most frequently occurring abnormal condition is an excessive flow of current, which may be due to overloading motors, or to short-circuits in the receiving, transmitting or transforming apparatus. Other abnormal conditions that may occur are undercurrent, undervoltage or overvoltage, in a constant-potential circuit. The last-named might be caused by an increase in prime-mover speed, or short-circuit in field resistor, and result in a burning out of lamps or motors. For protection against these conditions and also for protection against excess current (overload) when it is of such frequent occurrence that the renewal cost of fuses is prohibitive, an automatic switch, called a circuit breaker, is commonly employed. Circuit breakers are usually arranged to open on the occurrence of excess current, but may be provided with attachments or releases which actuate the breaker on the occurrence of undercurrent, overvoltage and undervoltage. For such conditions as reverse current, reverse power, reversed phases, excesses in temperature or frequency, or obtaining specific time delay between the instant of excess current and opening of the breaker, and to obtain accuracy in the measurement of the excess current or voltage and undervoltage and current, it is usual to control the opening of the breaker by protective relays. Circuit breakers may open the circuit in air, as in Fig. 1, or under oil. The first are commonly called "carbon-break circuit breakers" because the final break is between carbon contacts, and the second kind are often called "automatic oil switches" or "oil circuit breakers." Breakers may be semi-automatic, full automatic or electrically operated. A semi-automatic circuit breaker is one that opens automatically on the occurrence of an abnormal condition, but must be closed by hand, and if the handle is held in a closed position, the breaker is inoperative. In the full automatic breaker the handle is said to be "trip-free"; that is, if the breaker has opened owing to an abnormal condition, and attempt is made to reclose it by hand, then if the abnormal condition still exists, the breaker will open even though the handle be held in the closed position. An electrically operated breaker is one that is both closed and opened electrically. The opening is usually due to an abnormal condition, but the breaker may be either opened or closed from some remote source; for instance, a remote-control panel board or a protective relay.

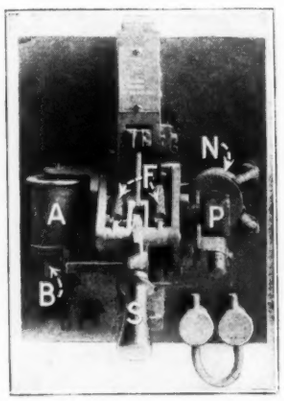
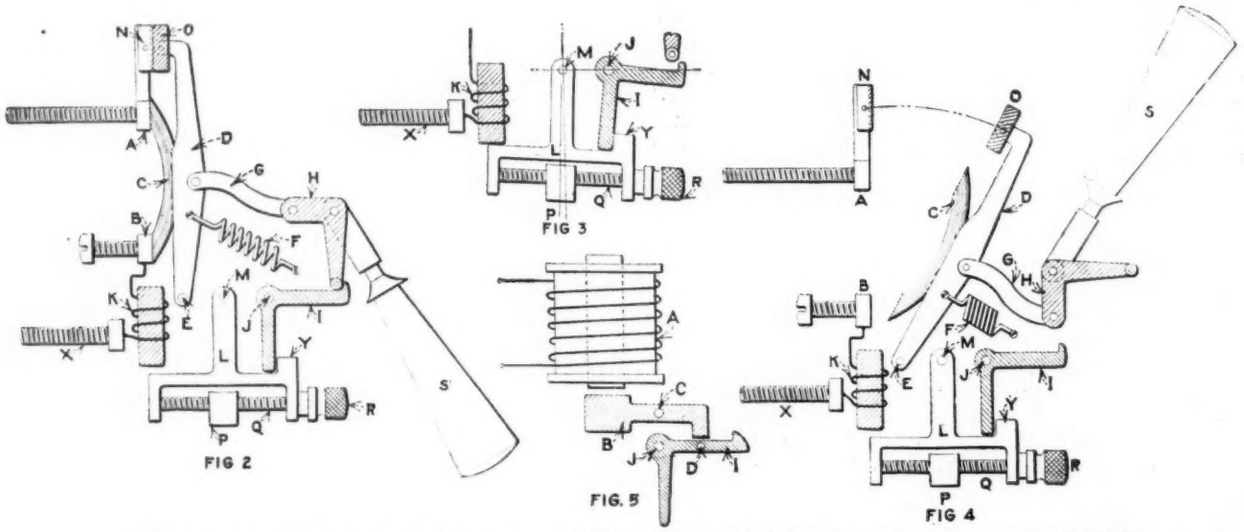


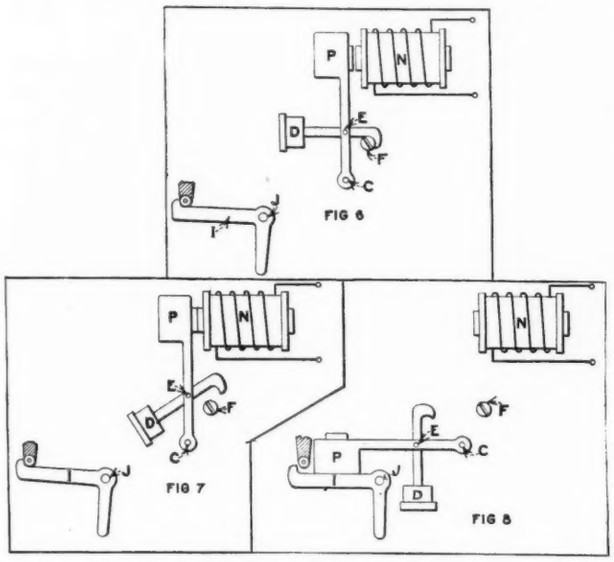
FIG. 1. CIRCUIT-BREAKER WITH SHUNT-TRIP AND UNDERLOAD RELEASE



FIGS. 2 TO 5. SCHEMATIC DIAGRAMS SHOWING PARTS OF CARBON-BREAK CIRCUIT BREAKER

Circuit breakers are usually arranged so that when they are closed, considerable energy is stored in strong springs and the parts held in a closed position by a small trigger or tripping lever. When the predetermined conditions occur for which the breaker is set, this trigger is tripped, thereby releasing the springs, which causes the contacts to open in a small fraction of a second. This may be readily seen from the

schematic diagram of parts of a typical carbon-contact circuit breaker, Fig. 2, which shows the breaker in its normally closed position. *A* and *B* are the main contacts (usually heavy copper blocks), which are spanned by the laminated copper brush *C*. This is loosely attached to the moving arm *D* in such a manner



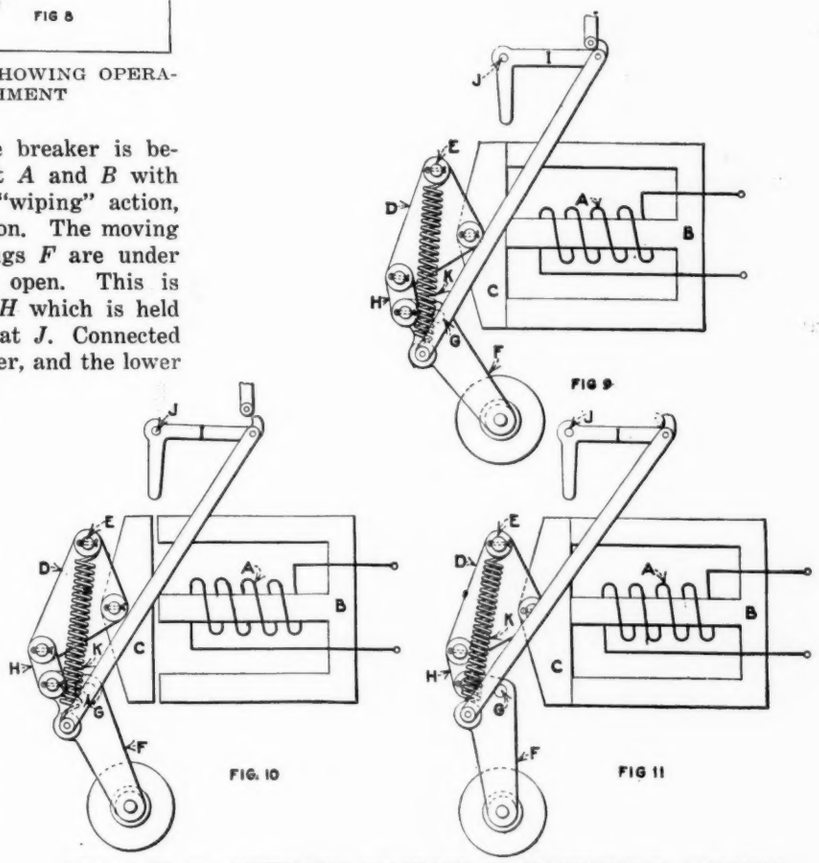
FIGS. 6 TO 8. SCHEMATIC DIAGRAMS SHOWING OPERATION OF UNDERLOAD ATTACHMENT

that it is self-aligning, and when the breaker is being closed, contact *C* is forced against *A* and *B* with considerable pressure, resulting in a "wiping" action, which makes a good electrical connection. The moving arm *D* is pivoted at *E* and the springs *F* are under tension, tending to pull the contact open. This is prevented by the toggle joint *G* and *H* which is held in position by the trigger *I*, pivoted at *J*. Connected between the lower stud *X* on the breaker, and the lower main contact *B* is a coil *K*, which carries the main current; and under its influence is an iron armature *L*, pivoted at *M*. When the current in coil *K* becomes great enough, the armature *L* is attracted to its core; this causes the projection *Y* on the armature to strike the tripping lever *I* a sharp blow, thereby releasing the toggle joint and allowing the springs to open the contacts quickly. In Fig. 3 is shown the breaker's trip mechanism just at the instant of tripping, and Fig. 4 shows the breaker fully open. In order to reset the breaker, handle *S* must be pulled down, thereby straightening the toggle joint and giving the necessary power to force the contacts closed. If the main contacts, *A*, *B*, and *C*, were to open the circuit directly, the resultant arcing would soon cause them to become so pitted that they could no longer make contact. Therefore, the circuit is finally broken by two auxiliary carbon contacts at *N* and *O;* when the main contacts open, the current is shunted through these contacts, but they are separated so quickly that no arc or excessive burning results, the oxide of course passing off as a gas.

In order to allow a variation in the tripping current required, the armature *L* is provided with a threaded weight *P*, which is mounted on a screw *Q*, so that the former's position may be varied by turning the nut *R*. When the weight is near the electromagnet *K*, its full weight tends to keep the armature away from the magnet, thus requiring the maximum current to cause tripping; when it is near the nut *R*, its weight tends to assist the attraction of *K*, thereby requiring a minimum of current.

Provision is usually made to open the breaker by hand. The type of breaker shown in Fig. 2. can be opened by raising the handle *S*, which results in tripping. Many operators prefer to touch the trip lever *I* or the nut *R* to open the breaker, but this should be done with care, since this part is "alive" and there may be danger of a severe shock. Many breakers provide for opening in this manner by using a well-insulated nut at *R*, thus preventing danger of accidental shock.

It will be readily seen that anything that trips the lever *I* will cause the breaker to open. The shunt trip is a device for tripping the breaker from some remote source, either manually or automatically. In Fig. 5 is shown the trip lever *I*, pivoted at *J*, with the other



FIGS. 9 TO 11. SCHEMATIC DIAGRAMS OF ALTERNATING CURRENT UNDERVOLTAGE RELEASE

parts shown in Fig. 2 omitted for clearness. The electromagnet *A* is wound with many turns of fine insulated copper wire and is mounted on the side of the breaker, as shown at *A* in Fig. 1. When this electromagnet is energized, it attracts the iron armature *B*, pivoted at *C*, and causes it to strike a stud *D* on the tripping lever *I* and trips the breaker, as described in

the foregoing. The shunt-trip attachment is the device usually employed when protective relays are used; upon the occurrence of conditions for which it is set, the relay closes the circuit to the shunt-trip coil, thereby opening the breaker.

There are cases not important enough to warrant the use of accurate relays, where a circuit must be protected from damage due to reverse current or underload. For instance, if for any reason the voltage of the charging source of a storage battery decreases below that of the battery, the latter may attempt to assume the load, or to motorize the generator. However, the instant the current drops to zero, as it must do before reversing, the breaker may be tripped by an underload attachment.

The principle of operation of a breaker with an underload attachment is shown in Fig. 6. The tripping lever is represented by *J* and *I* as before, and the device is shown ready to apply current. An electromagnet *N* carrying the main current is mounted on the side of the breaker, as shown in Fig. 1. The heavy iron armature *P*, pivoted at *C*, has on its side a small lever *D* which is pivoted at *E* and is manually hooked over the stud *F*, Fig. 6, thereby holding the armature a slight distance from the electromagnet. When the electromagnet is energized, it attracts the armature *P* to the position, Fig. 7, thereby releasing the catch-lever *D*. Now should the current fail, the armature *P* is no longer attracted and from its own weight falls down to the position shown in Fig. 8, striking the trip lever a sharp blow and tripping the breaker. Care must be taken that the device sets itself when current is applied; that is, the iron weight must be attracted and the lever *D* released, otherwise the device will not operate on the cessation of current.

The foregoing device, when wound with many turns of fine wire, may be used as a direct-current undervoltage release, operating when the voltage drops to a predetermined amount. On alternating current the electromagnet must have a closed magnet circuit, therefore the armature must be in the same position (closed air gap) in both operating and tripped position. This is accomplished by a toggle-joint arrangement as shown in Fig. 9. *I* and *J* represent the trip lever as before. The coil *A* is wound on a laminated iron core *B*, which with the armature *C* forms a closed magnetic circuit. Attached to the back of the armature is a triangular piece *D*, pivoted at *E*, which is connected to the setting lever *F*, pivoted at *G*, by the link *H*, which forms a toggle joint. The spring *K* tends to rotate *F* in a clockwise direction, and this by attempting to straighten the toggle, would tend to give *D* a clockwise rotation also and pull the armature away from the electromagnet. This is prevented by the energizing of *A*.

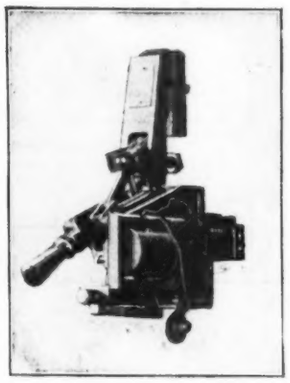


FIG. 12. CIRCUIT BREAKER WITH A.-C. UNDERVOLTAGE RELEASE

As soon as the voltage drops to a predetermined amount, the armature is pulled away, allowing the springs *K* to move the lever *F*, thereby tripping the lever *I* and causing the breaker to open. This position is shown in Fig. 10. But the spring pulls the lever *F* farther than the tripping position, and this causes the link *H* and piece *D* to force the armature *C* back against the electromagnet, Fig. 11, thereby again completing the magnetic circuit and preventing the coil *A* from burning out should the voltage come on again before the device was reset. Resetting is accomplished simply by moving lever *F* to the position in Fig. 9. A breaker with this form of release is shown in Fig. 12. For an overvoltage release a device somewhat similar to the shunt-trip attachment is used, but is usually designed with the heavier magnetic circuit to allow a smaller energy loss. An overvoltage release is shown on the breaker in Fig. 13. The solenoid *S* is wound on a heavy iron casting and has in its center an iron plunger. When the voltage increases to a certain amount, the plunger P is drawn upward, striking the pivoted lever *L*, which in turn strikes the projection on the trip lever and trips the breaker.

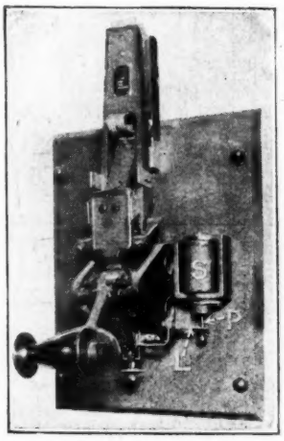


FIG. 13. CIRCUIT BREAKER WITH OVERVOLTAGE RELEASE

While practically every make of breaker varies in detail of construction, and in fact each manufacturer may turn out various designs of breakers, yet the principle of operation is practically the same in all, and the foregoing examples are typical of the devices usually employed.

Suggestions for the Semi-Diesel Engineer

On starting the engine, do not inject too much fuel oil. Two strokes of the hand lever should be sufficient. If an excessive amount of oil is used there is great danger of blowing the cylinder-head joint.

In old engines where the usual copper gasket fails to keep the head joint tight, try using asbestos wicking braided into a rope. This should be soaked in salt water and then covered with graphite and oil before using.

In installations where the starting torch is fitted with a heating coil, small carbon particles will choke the coil; a spare torch should be always on hand. The coil can be cleaned by soaking in lye water and then blowing out with air.

In starting a semi-Diesel engine, the torch should be forced to cause the ignition plug to be heated in the shortest possible time. Slow heating causes the entire cylinder to become hot. Since no cooling water is flowing, the cylinder-head gasket is often ruined by this.

The proper temperature of the ignition device, whether it be a bulb or plate or pin, depends on the compression pressure carried. In engines having a pressure of 70 to 90 lb. the bulb must be cherry red. Higher pressures require lower temperatures; in engines of 160 to 200 lb. compression, the bulb of plate need never be other than black in color.

Operation and Adjustment of Turbine Machinery VIII—Packing Clearances

By EUSTIS H. THOMPSON
Consulting Engineer, Baltimore, Maryland

WHEN fitting carbon rings to small turbines of 100 kw. or under, it is well to make them slightly smaller than the shaft, say 0.002 in. or 0.003 in. in diameter. These rings will wear to normal size in two or three hours' operation and give better results than the most accurate fitting and measuring usually accomplish.

On large turbines this procedure would not be advisable, as vibration or heating would probably be set up This should not be done in the case of diaphragm packing in any machine, as the slightest binding of an inter-

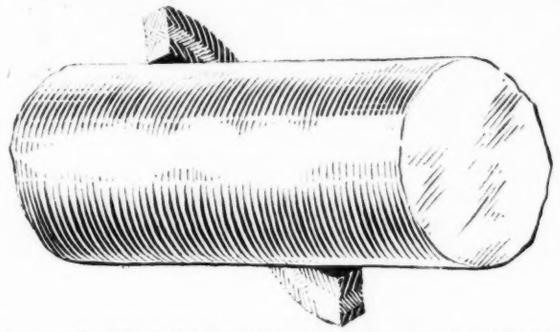


FIG. 1. IF THE METAL RING PACKING WILL NOT GO IN WITHOUT BREAKING, CUT EACH RING IN HALF AND STAGGER THE JOINTS WHEN INSERTING

stage ring will quickly set up vibration. It should be borne in mind, however, that it is better to err in making the celarance over the shaft too small rather than too large. Harmful effects seldom happen if the ring is larger than the shaft by even a slight amount. The wear will rapidly increase the diameter to normal running fit.

Another kink in fitting packing is to have a mandrel made the exact size for which the carbon packing is to be fitted. The ring can be tried around this mandrel and fitted accurately without difficulty. A piece of iron pipe can easily be turned up to the proper dimension.

New packing from the factory is sometimes too large and can to advantage be made smaller by a few thousandths by the foregoing method.

Metallic or labyrinth packing is fitted in the same general way as carbon packing. The joint surfaces are often reduced most conveniently by placing the entire number of segments in a shaper and taking them down by machine. If the segments are quadrants, it is often possible to machine them both horizontally and vertically with one setting so that both surfaces can be finished without changing the setting of the clamp.

Be careful in boring the rings to see that the sawtooth surfaces are not too thick where they touch the shaft. It may be necessary to cut into each tooth to bring these to a sharp edge to make them wear easily when in contact with the shaft. If dowels are present, they should, of course, be removed from the joints while these surfaces are being machined and then replaced when the ring is assembled for boring. It may be noted that the joint surfaces are especially important in the last ring which is exposed to view, as any slight leakage in this ring will immediately be seen.

The axial clearance of the packing rings should be smaller than the groove in an axial direction of 0.003 in. to 0.006 in. If the clearance is less than this, rust and sediment are likely to cause the ring to stick. If the clearance is appreciably larger, it often happens that the steam pressure in the axial direction will not cause the ring to move tightly against the diaphragm surface. The engineer should check these clearances on new packing from the factory; ordinary judgment is all that is necessary in usual cases. Special cases may occur where the limits mentioned can be overstepped, but in general practice this is correct.

The joint surfaces should be held closely together by spring pressure to prevent leakage between them, and also for the reason that when they are forced apart the leakage between the shaft and ring becomes excessive. Spring pressure for holding the ring together should be from 2 to 4 lb. per square inch of area of the inner

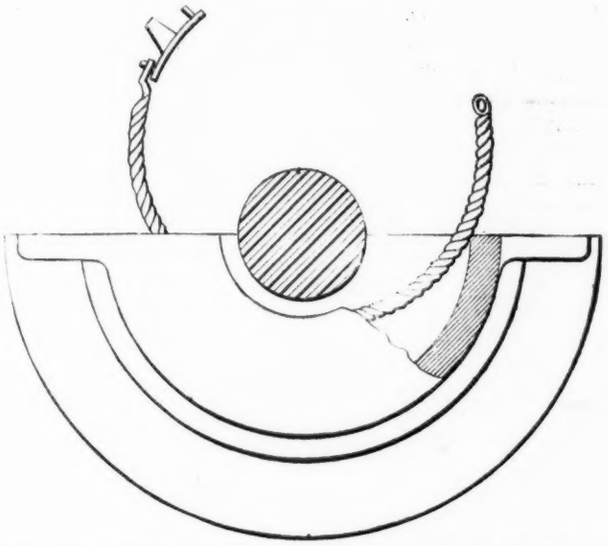


FIG. 2. GARTER SPRING PACKING CAN USUALLY BE PUT IN EASIEST BY PUTTING IN THE LOWER HALF OF THE CASING FIRST

surface of the ring. Many cases have been noted where leakage was hard to explain but was remedied by this means.

Some manufacturers equip the last ring which is exposed to view with lap joints, which do not butt together. In other words, there is a clearance in the joints so that the ring is not arch-bound but bears upon the shaft throughout its whole extent, being held there by spring pressure. This plan is used only where practically no steam pressure can act upon the ring, and in refitting such packing the joints should be filed so that the ring bears firmly upon the shaft and is not arch-bound.

Shaft packing is seldom easy to assemble on account of the requirements of turbine design. The packing

is necessarily placed in an inconvenient position. On account of conditions of the shaft the space is limited and a great deal of ingenuity is often required to assemble properly. It is frequently necessary to work on a machine just as soon as it has been shut down and to handle the parts while they are at a high temperature. Also, it is necessary to do a good job to prevent the appearance of leaking, which is the most noticeable defect that can occur on a machine. This matter, therefore, is worth a little thought and investigation.

The stuffing-box type of packing is refitted much like an ordinary packing gland. When the old packing has become hardened and worn, it should all be removed and new packing rings installed. The metallic rings which come already prepared are not easy to handle. Do not spread the ends apart in slipping them over the shaft, as this will cause the packing in the middle of the ring to become disarranged so that it will not assemble properly. Instead of spreading the two ends, bend one in one direction and the other in the opposite so that the strain is well distributed (see Fig. 1). If it

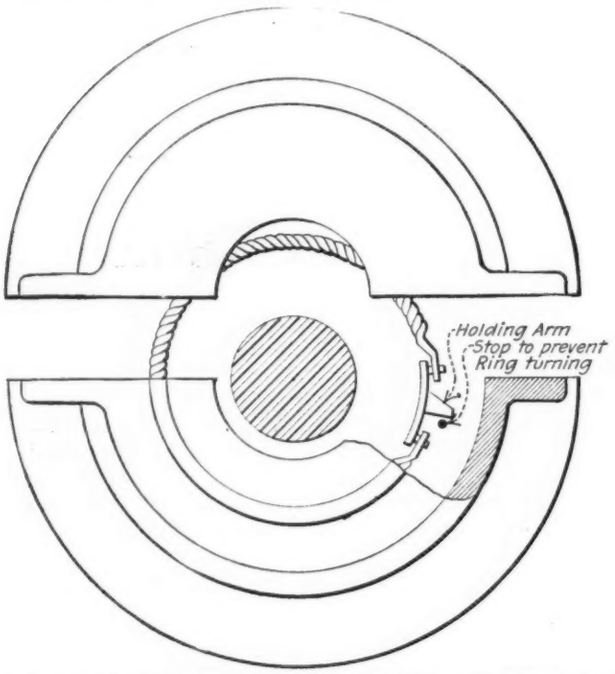


FIG. 3. WITH GARTER SPRING PACKING MAKE SURE THE KEY AND HOLDING ARM ARE PROPERLY LOCATED

is found that the ring cannot be assembled over the shaft without making it come to pieces at some place, it is better to cut it in half and assemble the various rings in the stuffing box with their joints staggered.

Before assembling new packing, it is well to cover the shaft and gland with cylinder oil and powdered graphite. This assists in allowing the ring to take its proper position. Do not make it tight. It is best to tap the rings in place with a piece of wood and a light hammer and then bring the follower up fairly to the rings. Run the machine up to full speed and then shut down and tighten to the follower if necessary. The packing will heat immediately if tightened the least bit too much while the machine is running.

Packing of this kind often makes a popping sound when a small particle of steam leaks through. This is perfectly natural and should not cause apprehension. It is needless to say that old hard packing should not be left in the gland when new packing is installed. Also, a good cleaning should be given the various parts of the gland.

Garter-spring packing can usually be most conveniently assembled by installing the lower half of the packing casing first. The garter springs should then

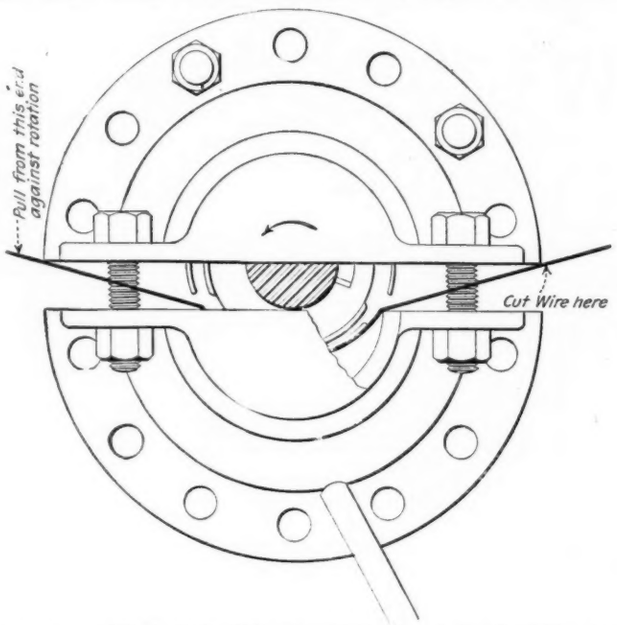


FIG. 4. AFTER THE TOP HAS BEEN PUT IN PLACE AND HELD BY A COUPLE OF BOLTS, THE WIRE IS CUT

be pushed through the grooves (see Fig. 2). The packing rings can now be assembled, taking care that the proper joint surfaces match each other in accordance with the numbering on each joint. The springs can then be connected, making sure that the key and holding arm are properly located (see Fig. 3). The proper "dope" should now be applied to the joint surface of the packing casing itself, and the top of the casing can then be assembled and the entire casing bolted home.

The flat-spring type of carbon ring does not need much skill when the rings are placed in recesses in a

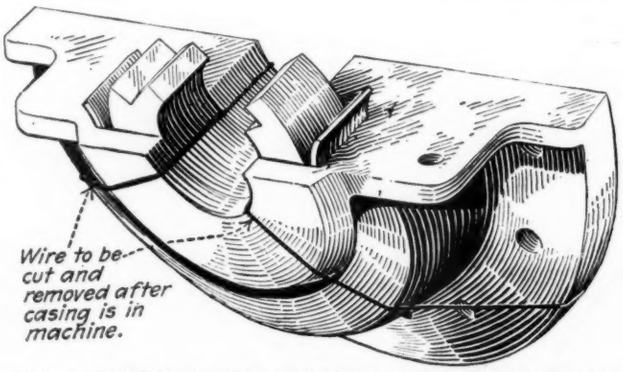


FIG. 5. PACKING RINGS, HOLDERS AND COPPER RIBBONS ARE PUT IN THE HOLDER AND HELD BY THE WIRE, WHICH IS PULLED OUT WHEN THE HOLDER IS PUT ON THE SHAFT

turbine casing. Those rings, which are contained in the packing casing itself sometimes require considerable patience, ingenuity and skill in assembling. The first ring is assembled in a recess of the turbine casing. The second ring is contained in the packing casing itself. The upper part of the casing, which has been cleaned

and covered with proper "dope," is assembled with one piece of carbon and holder in place. This is tied with a piece of wire, as shown in Fig. 4. After the top has been put in place and loosely fastened with a few bolts, the wire is cut and removed so that the carbons and

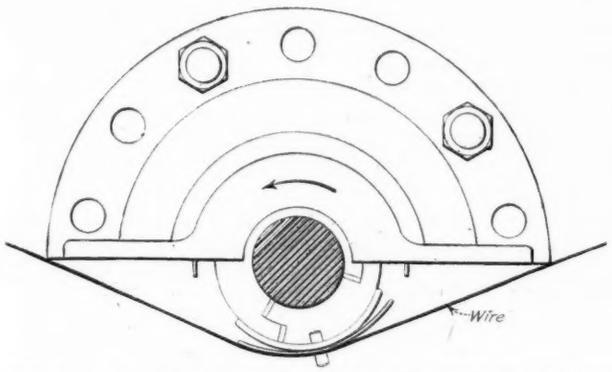


FIG. 6. PULL THE WIRE OUT AGAINST THE DIRECTION OF ROTATION OF THE SHAFT

holders are now in place. The other two pieces of packing ring, together with their holders and the copper ribbons covering the joints, are placed around the shaft and held tightly in place by a piece of wire, as shown in Fig. 5. The entire ring should be turned against rotation so that the stop on the upper holder will lack a quarter of an inch from touching the holder arm. The bottom casing, Fig. 6, can now be put on and brought into place, as far as possible without binding the wire; usually, an opening of $\frac{3}{4}$ in. to $\frac{1}{8}$ in. should exist between the joint surfaces of the upper and lower packing casing. The wire can now be cut with a pair of pliers on the proper side so that it can be pulled out in a direction against rotation. If it is pulled with rotation, the arms and stops are apt to bind the wire. Do not use a cord, as it may break off inside the casing.

The top part of the packing is shown as being assembled before the bottom part. This is often the necessary procedure, as nozzle chests or other parts of the turbine are placed just above the carbon-packing holder so that the top cannot be lowered vertically. This construction is indicated in Fig. 1. The top half must be placed in an inverted position against the bottom of the shaft and then rotated around it to the top position, where a few bolts can be entered and the wires cut as described. Whenever it is possible to assemble the bottom part of the carbon-packing holder first, this is usually the easiest method of procedure rather than beginning with the top half.

The wire should be about $\frac{1}{64}$ in. to $\frac{1}{32}$ in. in diameter, or No. 20 to 25 wire. A good quality of fishline of this size can be used, but ordinary cord or twine will not safely withstand the necessary pulling.

Checking Four-Wire Three-Phase Watt-Hour Meter Connections

By H. C. YEATON

Diagrams of connections are given for connecting a four-wire three-phase meter to the circuit, with both current and potential transformers, with current transformers only and also without transformers. Methods of checking the correctness of the connections are given in detail.

A FOUR-WIRE three-phase watt-hour meter consists of two elements, and each element has two current coils and one potential coil. One current coil of one element is connected in series with one current coil of the other element. As shown in the figures, current from all three phases goes through the current coils in the meter. Each of the potential coils of the meter is connected across one line and the neutral. As the current from all three phases goes through the meter, the meter will record correctly either a balanced or an unbalanced four-wire three-phase load. The connections shown in Fig. 2 are those for the meter when only current transformers are used, and Fig. 3 gives the connections when the meter is connected into the circuit without transformers.

When connecting the meter in the circuit, it should be ascertained that the potential transformer connected across line *A*, Fig. 1, and the neutral and the current transformer in line *A* are connected to the upper element of the meter. Likewise the potential transformer connected across line *C* and the neutral and the current transformer in line *C* must be connected to the lower element of the meter. Care should be taken that the current and potential transformers are connected correctly in regard to their polarity. Modern meter and instrument transformers have one primary and one

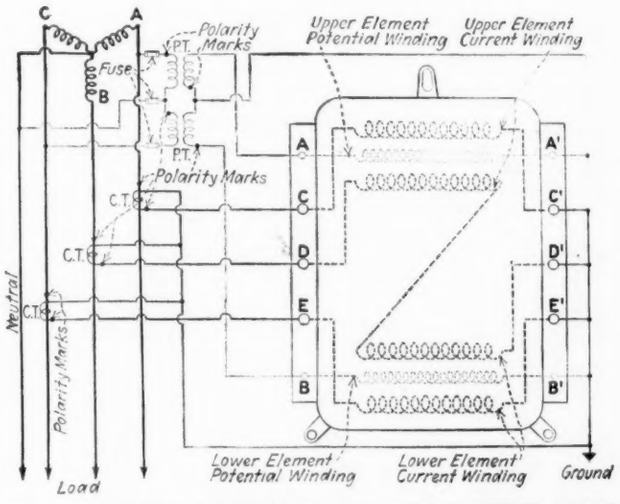


FIG. 1. METER CONNECTED TO CIRCUIT WITH BOTH CURRENT AND POTENTIAL TRANSFORMERS

secondary terminal marked, which indicates that if the instantaneous current flows into one marked terminal, it passes out of the other marked terminal. The secondary of a current transformer should at no time

be left open when there is current flowing through the primary of the transformer. If, for any reason, the secondary leads of a current transformer are disconnected from the meter, they should be connected together in some manner, so that there is no possibility

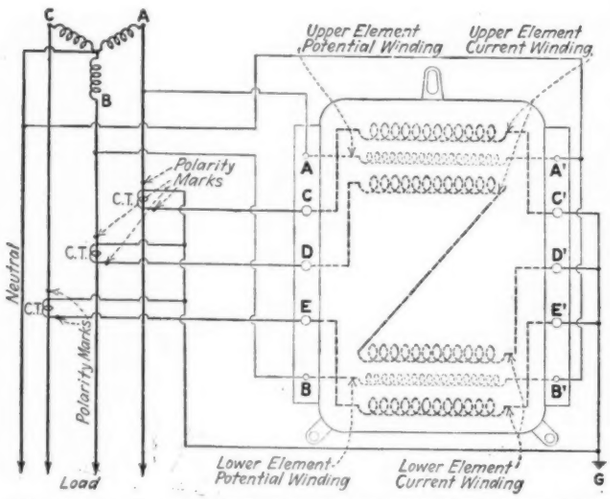


FIG. 2. METER CONNECTED TO CIRCUIT WITH CURRENT TRANSFORMERS ONLY

of the secondary circuit of the transformer being opened. To ascertain that the meter is connected correctly in the circuit, the following method may be employed:

After the meter has been connected in the circuit as indicated in the diagrams, disconnect the current leads of terminals *CC'* and *EE'*, Fig. 1, and if the remaining

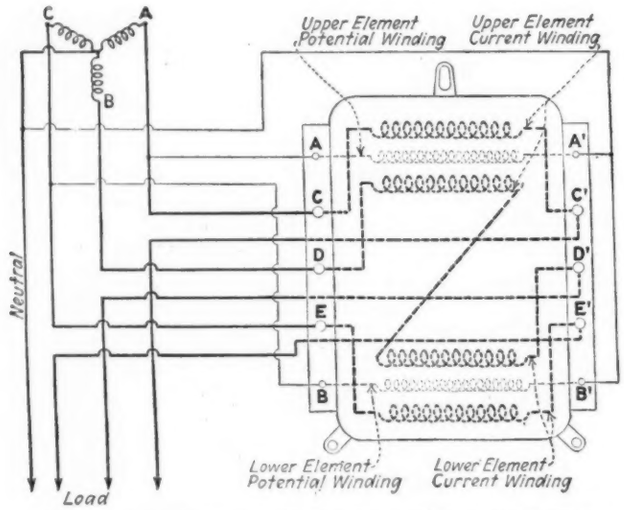


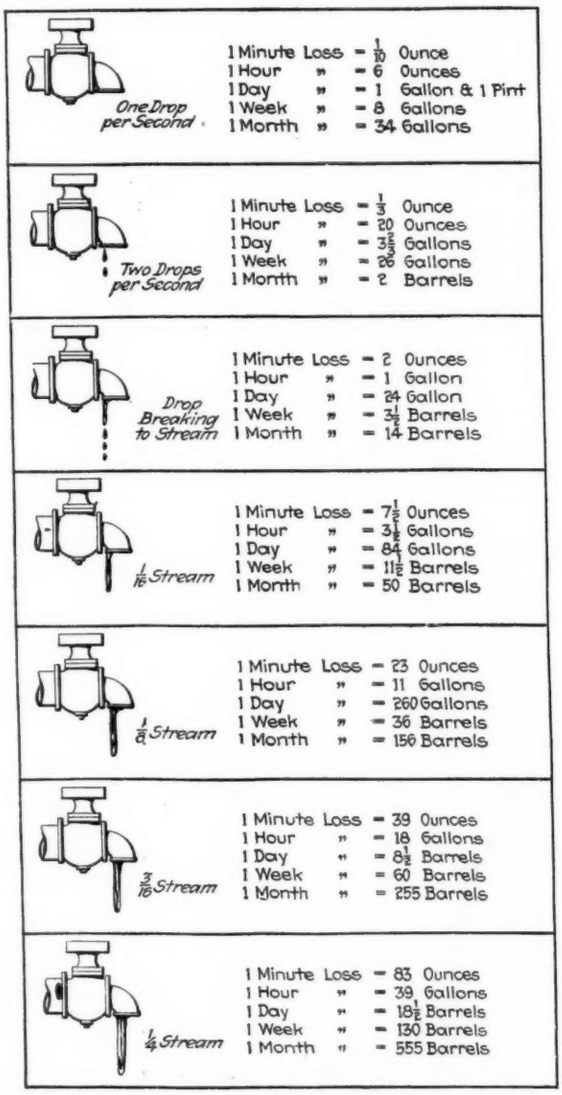
FIG. 3. METER CONNECTED TO CIRCUIT DIRECTLY

connections are correct the meter will rotate in the right direction if a load is on the circuit. If the potential coils *AA'* and *BB'* are connected wrong, the meter will rotate in a backward direction. To make the element rotate in the correct direction, it is necessary to reverse leads to both potential coils *AA'* and *BB'*. If the meter will not rotate in either direction, it indicates that the leads to one potential coil are incorrectly connected, and to the other are correctly connected. Now if the leads to the potential coil, that are connected correctly, are reversed, the meter will rotate backward, and it would then be necessary to reverse the leads to both potential coils *AA'* and *BB'* to obtain proper rotation of the meter. If, on the other hand, the leads to the potential coils that were incorrectly connected were reversed at first, the meter would rotate in the correct direction, and this would indicate that the connections to terminals *AA'* and *BB'* and *DD'* are right.

The next procedure is to disconnect the current leads of the current transformer in line *B* from terminals *DD'* and connect the current leads from the transformer to the terminals *CC'* so that the moving element rotates in the right direction. Now disconnect the current-transformer leads from terminals *CC'* and connect the leads from the current transformer line *C* to the current terminals *EE'* so that the moving element of the meter will rotate in the right direction.

It is obvious, from the foregoing, that if each current coil is connected separately, with the potential coils of the meter excited, so that the moving element of the meter rotates in the right direction, then it is certain that the meter is recording correctly.

Amount of Oil Lost Due to Small Leaks


One Drop per Second
1 Minute Loss = 1/10 Ounce
1 Hour " = 6 Ounces
1 Day " = 1 Gallon & 1 Pint
1 Week " = 8 Gallons
1 Month " = 34 Gallons
Two Drops per Second
1 Minute Loss = 1/3 Ounce
1 Hour " = 20 Ounces
1 Day " = 3 2/3 Gallons
1 Week " = 26 Gallons
1 Month " = 2 Barrels
Drop Breaking to Stream
1 Minute Loss = 2 Ounces
1 Hour " = 1 Gallon
1 Day " = 24 Gallon
1 Week " = 3 1/2 Barrels
1 Month " = 14 Barrels
1/16 Stream
1 Minute Loss = 7 1/2 Ounces
1 Hour " = 3 1/2 Gallons
1 Day " = 84 Gallons
1 Week " = 11 1/2 Barrels
1 Month " = 50 Barrels
1/8 Stream
1 Minute Loss = 23 Ounces
1 Hour " = 11 Gallons
1 Day " = 260 Gallons
1 Week " = 36 Barrels
1 Month " = 156 Barrels
3/16 Stream
1 Minute Loss = 39 Ounces
1 Hour " = 18 Gallons
1 Day " = 8 1/2 Barrels
1 Week " = 60 Barrels
1 Month " = 255 Barrels
1/4 Stream
1 Minute Loss = 83 Ounces
1 Hour " = 39 Gallons
1 Day " = 18 1/2 Barrels
1 Week " = 130 Barrels
1 Month " = 555 Barrels

The Atlantic Lubricator

The Principle of the Prony Brake Briefly Explained

By Charles C. Phelps

The prony brake is one of the simplest pieces of apparatus, and still many of those who use it for determining brake-horsepower directly from the shaft do not understand how and why it works. This was shown to be the case when a number of engineering students were asked recently how they accounted for the heat that developed in the brake and was dissipated. For example, in the type of prony brake illustrated by Fig. 1 cold water is fed continuously into the groove within the rim of the wheel and is removed at a much higher temperature, if in fact it is not converted into steam. Most of the students admitted that they had never thought about the loss of heat and were of the opinion that some correction should be applied, for the heat generated certainly represented energy. Let us see why it is not necessary to do this.

All the power supplied by the rotating shaft is utilized in overcoming the friction of the brake. That power would be $2\pi BF$, or $2\pi BW$ foot-pounds per revolution. Expressed in horsepower this would be $\frac{2\pi BWN}{33{,}000}$ = horsepower. The weight of the rope is not a factor because it is equally balanced in weight on either side of the wheel.

Knowing that it would require the same amount of power to overcome friction in case 1 as in case 2, all that is necessary to determine the brake-horsepower of the engine is to determine the weight W that will remain fixed in position, determine the number of revolutions per minute of the engine shaft, the diameter of the wheel and of the rope and apply the foregoing formula.

Many other variations of the arrangement shown in Fig. 1 are in use. For example, the loose end of the rope is sometimes conveniently attached to a spring balance as indicated in Fig. 3. When that arrangement is adopted, the net weight corresponding to W will then be $W_1 - w$. Other types use a lever clamped on one end to the rotating shaft with sufficient friction to produce the desired result and supporting a weight

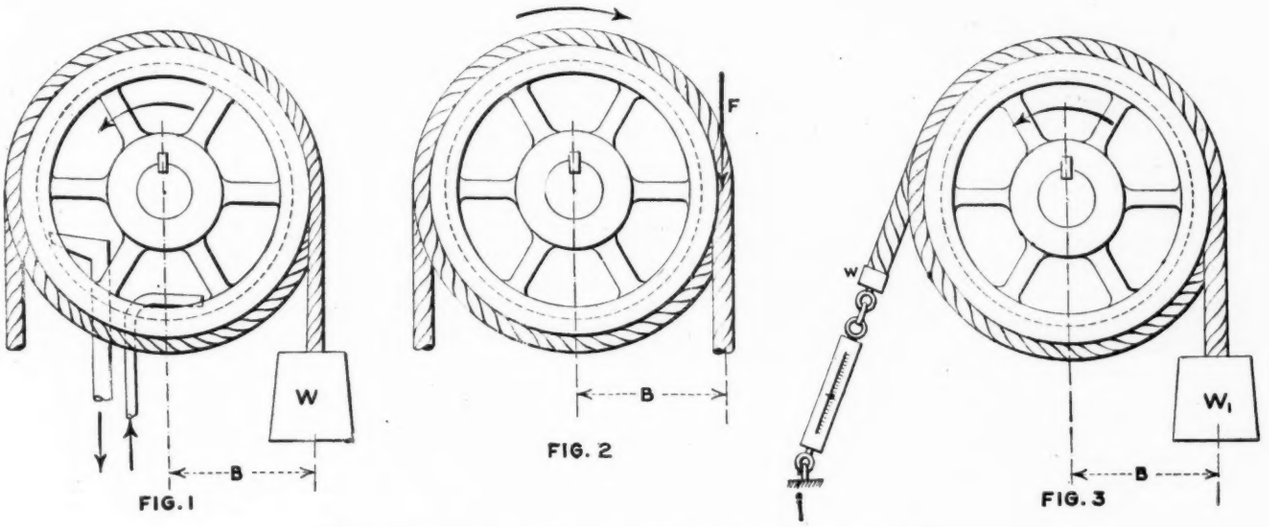


FIG. 1 FIG. 2 FIG. 3

SHOWING A FEW COMMON TYPES OF PRONY BRAKES

being the case, there would be the same amount of friction whether the rope with the weight W attached to its end remained stationary while the shaft rotated at the speed of N revolutions per minute, or whether the shaft remained stationary while the rope (under the same tension) revolved around the shaft at the same speed of N revolutions per minute.

Fig. 2 illustrates the second case. Here the shaft is stationary, while the rope rotates in the direction indicated by the arrow. The conditions are exactly the same as they were in the previous case excepting that the weight W is replaced by a continuously acting force F equal in amount to W, but acting tangentially to the periphery of the wheel. The power applied by this force in causing the rope to rotate would be equal to the force F in pounds multiplied by the distance in feet over which it acts. In one revolution, for example, the force would act over a distance equal to the periphery of the wheel, or more exactly the circumference of a circle whose radius is the radius of the wheel plus half the diameter of the rope. This on the other end or having the other end either attached to spring scales or pressing upon platform scales. No matter what method is adopted, the principle is the same in general and the explanation already given holds.

Another question arises at this point. If lubrication is not properly attended to, will not that change conditions to a marked degree? It will, most assuredly, but that question will take care of itself unless the surfaces become so dry as to seize. For example, in the case of an engine closely governed for speed, the effect of better brake lubrication would be to reduce friction, allow the weight W to descend and to increase the spring tension w. Thus the factor $W - w$ would be reduced, showing that the engine developed less horsepower. On the other hand, if better lubrication of the brake wheel resulted in an increase in the engine speed, the true horsepower would still be determined, because the factor N in the formula would take care of that. These are some of the things into which young students do not inquire.

The Diesel Engine and the Indicator

THE majority of steam engineers are familiar with the indicator, and many are quite proficient in using it in setting valves. Unfortunately, this is not true in respect to the Diesel-plant operator, although the Diesel engine requires the employment of an indicator far more than does a steam engine. The average Diesel engineer attempts to secure satisfactory valve timing by setting the valves while the engine is not running. In view of the cold condition of the parts, it is necessary when adjusting the valve rockers to allow some clearance to take care of the expansion of these parts when the engine warms up. Nevertheless, even though some allowance be made, correct valve functioning is very seldom attained in the Diesel engine. In respect to the exhaust and admission valves, usually the timing is fairly correct; a few degrees angular variation in the opening or closure of these valves has but slight effect on the quiet running of the engine, although a very late exhaust opening will cause a decided drop in the capacity of the unit. The fuel-valve timing, on the other hand, is of serious moment. In almost any make of Diesel a matter of three or four degrees in the point of fuel-valve opening will affect the capacity and economy of the engine from 10 to 20 per cent.

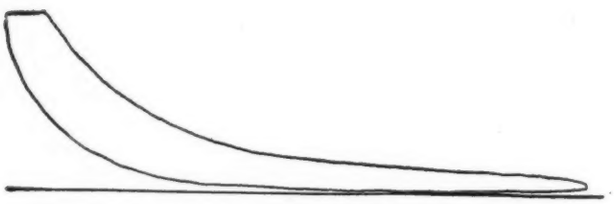


FIG. 1. PERFECT CARD

The indicator offers a ready means whereby the functioning of the various valves in the Diesel engine may be ascertained. Any misadjustment is revealed in the diagram. Engineers should become more conversant with the use of the indicator and with the interpretation of Diesel indicator diagrams.

Many of the more experienced operators can, or think they can, detect any improper functioning of the valve by the sound as the piston passes the top dead center. This is largely impossible, although a very early opening will be revealed by a severe pound as the piston approaches top center. The same sound is produced if the piston-pin bearing is slack. While the various types of Diesels are fairly consistent in the valve timing, all engines will require variation in the timing of the fuel-valve opening when the character of fuel oil changes. The point of opening is largely dependent upon the design of valve, size of openings in the atomizer discs, air pressure and compression pressure carried, and upon the characteristics of the fuel oil. It becomes apparent that the operator should not depend exclusively upon the valve timing as given by the engine builder, but should use an indicator and adjust the valves until a satisfactory diagram is secured. As with a steam engine, each defect in the valve timing produces certain peculiarities in the indicator diagram. In Fig. 1 is shown a card that is practically perfect. The fuel valve, which was set to open 5½ deg. ahead of top dead center, allowed the admission and combustion of the fuel to begin just as the piston reached top center. The rate of admission was such that the pressure behind the receding piston was maintained at a constant value.

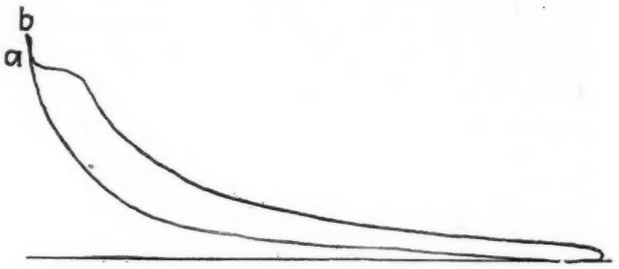


FIG. 3. ANOTHER EARLY INJECTION CARD

In Fig. 2 the diagram has a sharp peak at the end of the compression. The fuel valve opened early, and the combustion began before upper dead center was reached. The final cylinder pressure was considerably above the final compression value. It is easily understood that if the fuel starts burning while the piston is still on the compression stroke, the heat introduced into the rapidly diminishing cylinder volume may produce alarming pressures. Marine engines, especially while running at low speed, will show excessive pressures if the fuel-valve timing is not absolutely correct. Frequently, the peak at *b* is merely a line giving the card the appearance of Fig. 3. At first glance the line *ab* seems to be due to the inertia of the indicator parts, but changing the timing will show that the fuel valve has been early.

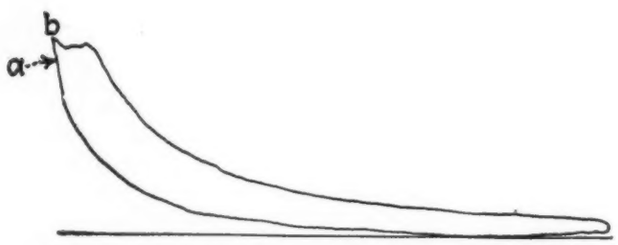


FIG. 2. CARD SHOWING EARLY FUEL INJECTION

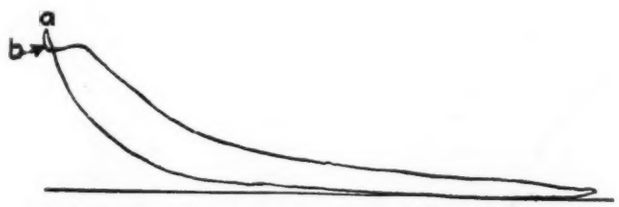


FIG. 4. EFFECT OF LATE FUEL-VALVE OPENING

Late fuel-valve opening compels the fuel-valve closure to be advanced so that the period of injection or admis-

sion is shortened. In Fig. 4 the fuel valve opened after dead center. The compression curve ended at *a*, and as the piston started on the power stroke, the cylinder pressure dropped sharply to *b*, where the fuel valve opened. Frequently, this line *ab* coincides with the compression curve, causing the diagram to resemble Fig. 3, where the timing was early. The proper precaution should be taken when a diagram similar to Fig 3 is secured; if the valve is early, a more advanced timing may cause the engine to pound. Undoubtedly, it is safer to set the valve late and then gradually advance the timing, taking indicator cards after each adjustment.

If a very low injection pressure is carried with a high compression, the card may have somewhat the appearance of Fig. 2. Usually, low injection air pressures produce a diagram quite like Fig. 5. Here the pressure is so low that the rate of introduction of the fuel is insufficient to maintain the cylinder pressure at a constant value.

When the engine is running under a light load such conditions are of advantage, since the low rate of fuel injection prevents the loss of air that occurs when a small oil charge is introduced very rapidly early in the period of fuel-valve opening. High injection pressure increases the velocity of fuel injection, and the consequent rapid combustion increases the heat in the cylinder at such a rate that the pressure experiences a decided rise. High air pressures often cause the indicator diagram to have the form of Fig. 6.

Frequently, the combustion line has a downward slope as in Fig. 7. This has the appearance of the ideal diagram as proposed by Diesel. At first glance the admission line seems to be an isothermal. The peculiar shape of this part of the diagram is traceable to the leaky condition of the piston rings. The gases were able to blow down past the piston almost as fast as the fuel

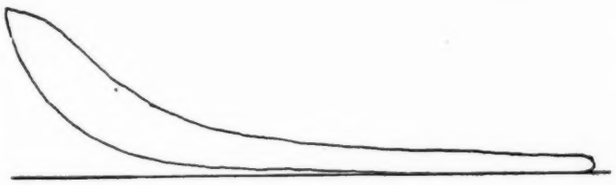


FIG. 5. CARD SHOWING LOW INJECTION-AIR PRESSURE

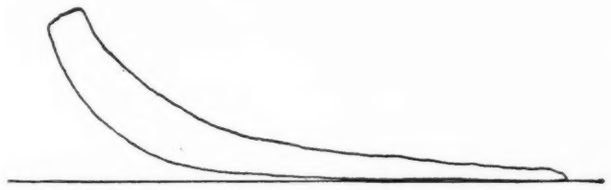


FIG. 6. CARD SHOWING HIGH INJECTION-AIR PRESSURE

was burned. Escaping gases in the crankcase and decided loss of power always accompany this condition.

High cooling-water temperatures will often cause the diagrams to appear quite like Fig. 8. The fuel, before admission to the cylinder, became so heated that the rate of injection at valve opening was very high. The pressure in the cylinder experienced a decided increase. The waves in the combustion and expansion lines are due to after-burning of the fuel.

The engineer of any plant containing a Diesel or semi-Diesel engine of over 100 hp. should invest in an indicator and at least once a month take a few diagrams. With these evidences of cylinder conditions before him it is quite easy to maintain the high efficiency of these types of engines.

Practically all engine builders are in a position to provide indicator rigging for their engines. In the event that this is impossible a mechanic can easily make a rig at a cost of less than fifty dollars. In the past too much has been taken for granted in the operation of

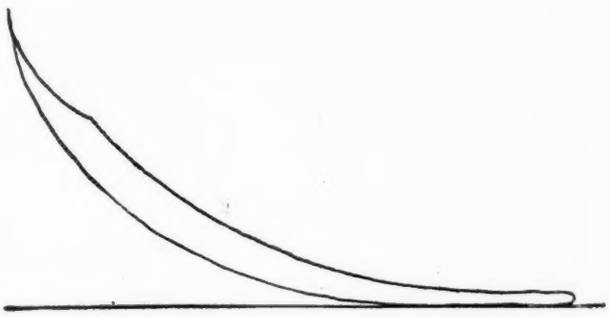


FIG. 7. EFFECT OF LEAKY PISTON RINGS

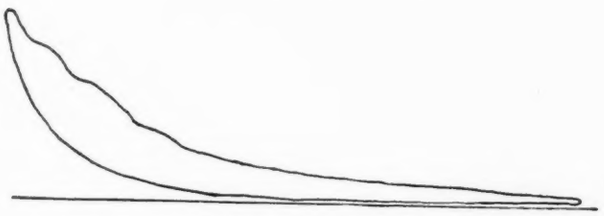


FIG. 8. EFFECT OF HIGH COOLING-WATER TEMPERATURES

internal-combustion engines. With fuel oil advancing in price, it is high time to give more attention to proper valve setting. In many Diesel-engined plants incorrect timing has increased the fuel consumption over 20 per cent; and even though the Diesel is an efficient machine, a 20 per cent saving in the fuel bill is not to be disregarded.

The Bureau of Mines is receiving many requests for an expansion of its fuel-inspection work. This work has been increasing in amount and importance. Several foreign Governments have called upon the Bureau of Mines to supervise the inspection of the coal which they had purchased in this country. The Bureau recently entered into a co-operative agreement with the Sewall Point Coal Exchange for the inspection of coal destined for separate pools at tidewater. For a number of years the coal that was used by most of the Government departments has been inspected by the Bureau of Mines.

Bituminous coal, carried as revenue freight during the first three months of 1920 on class 1 roads, totaled 90,622,867 tons, according to figures just made public by the Interstate Commerce Commission. The figures given do not include tonnage carried on roads having annual operating revenues of less than $1,000,000. The anthracite shipments during the same period amounted to 17,304,993 tons. The coke movement aggregated 7,075,275 tons. Class 1 roads carry 90 per cent of the country's total tonnage.

Typical Fires in Stored Coal

By W. D. LANGTRY
President, Commercial Testing and Engineering Company, Chicago, Illinois

THERE is no excuse for property loss from the spontaneous combustion of coal. This is true whether coal is stored in bins, yards, basements—any kind of outdoor or indoor storage. The process of oxidation is slow, and there is ample time to discover whether the coal is heating or not and thus eliminate any danger before damage can be done. Trouble, in other words, can be detected long in advance before ignition of any surrounding building or material of an inflammable nature takes place. Coal heated from spontaneous combustion does not break into flame until it reaches about 650 deg. F. This heating can be detected in several ways—by odor, using a maximum thermometer or inserting iron rods into the pile and feeling them with the hand.

There is a cause for every fire that starts in a coal pile from spontaneous combustion. Many theories have been advanced, many causes have been explained and chemistry has played its part in trying to solve the problem. Fires, however, will probably continue to appear in coal piles so long as the present methods of mining and sizing of coal are used and the present methods of unloading are followed. The consumer of coal or the dealer who places coal in his yard for storage hopes each year that he will "get by" without trouble, but in many instances he is hoping against hope. There is hardly a coal mined in the United States that has a "clean reputation" when it comes to spontaneous combustion; on the other hand, there is little coal mined that cannot be stored successfully if certain principles are followed and strictly adhered to.

During the summer of 1918 the Government rightly advised more storage of coal. In and about Chicago every coal yard, basement, specially constructed shed, vacant lot, etc., was well stocked. Much of this coal gave trouble from spontaneous combustion, affording a good opportunity for study. Pictures of many of the fires were made for permanent record, and conclusions were drawn as to what apparently caused the trouble. Much interesting information was obtained as to the history of the coal itself, how long it had been in storage and other facts that might help in arriving at the real causes of the fires.

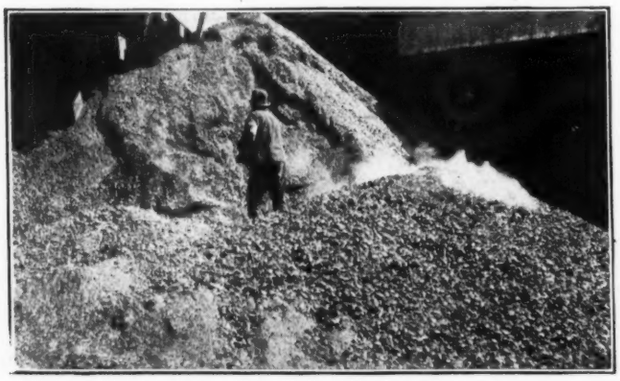


FIG. 1. FIRE STARTED IN THE MIDDLE OF A CONICAL-SHAPED PILE

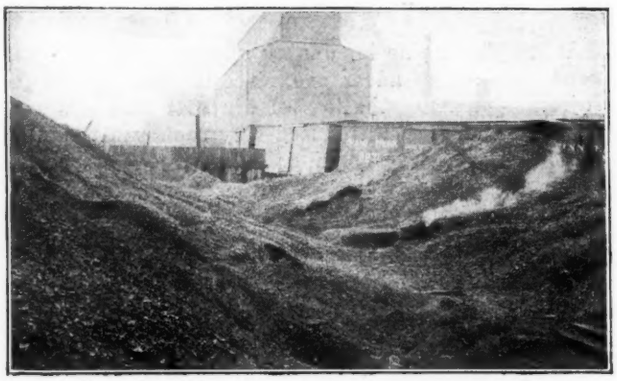


FIG. 2. FIRE STARTED JUST BENEATH A CRUST OF FINE COAL

FIG. 3. TURNING OVER A BURNING COAL PILE

FIG. 4. COOLING A COAL PILE WITH WATER

All this work was carried on under the jurisdiction of the United States Fuel Administration for Illinois. Through the co-operation of the Chicago Fire Department prompt notification was given of all fires in storage coal both night and day.

The causes of some of the fires may be attributed to the nature of the coal itself, the method of piling, attempted ventilation and to sources other than the coal itself. Some coals are far more susceptible to spontane-

ous combustion than others. These coals in themselves are conducive to rapid oxidation. Generally speaking, a coal high in sulphur and with an iron pyrites content will disintegrate and crumble or air slack, like lime, in two to four weeks' time. Coal of this character should receive special attention during the whole time it is in storage if it is desired to avoid combustion trouble.

impossible for consumers to accumulate storage piles, so that just now trouble from spontaneous combustion is at a low ebb. The pictures shown on this page and the one opposite are typical of what happens when the storage of coal is normal.

To obtain relief from excessive coal prices during the winter months, storage of coal is essential. To accom-

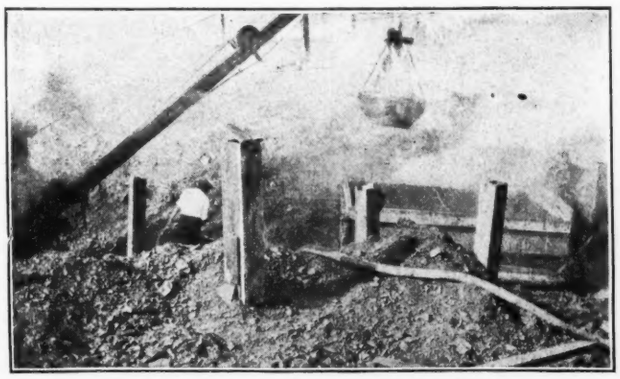


FIG. 5. A POOR ATTEMPT AT VENTILATING BY UPRIGHT VENTS

FIG. 6. **A LATER VIEW OF FIG. 2, SHOWING PILE OF COAL BURNING TO ASH**

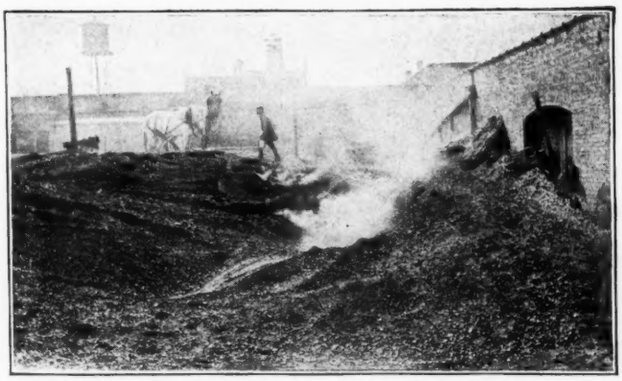


FIG. 7. **ATTEMPTED VENTILATION. NOTICE THE TWO UPRIGHT PIPES IN PILE**

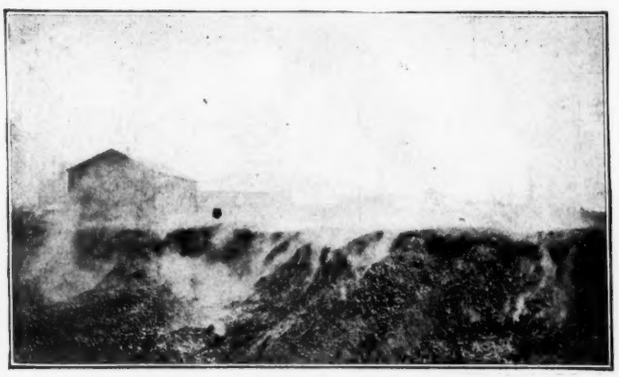


FIG. 8. **THE COAL IN THIS PILE WAS ALMOST A TOTAL LOSS**

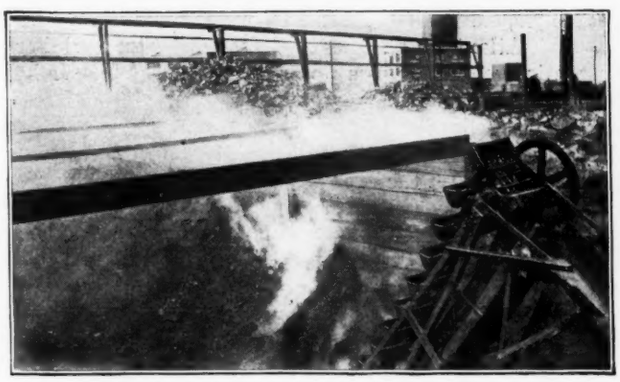


FIG. 9. **FIRE THAT STARTED IN SCREENINGS**

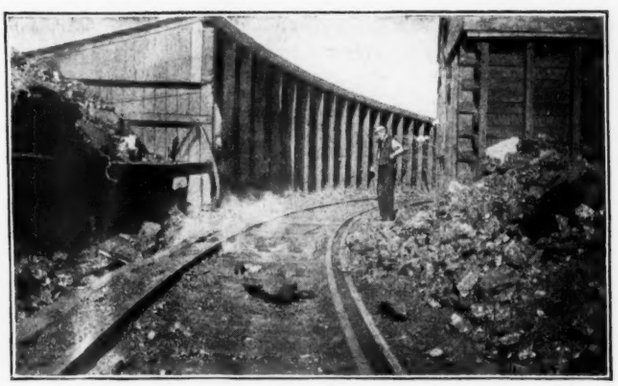


FIG. 10. **FIRE THAT STARTED IN MINE-RUN COAL**

It should be kept in mind that the finer the coal the more likely it is to catch on fire, the reason being that there are many more particles or surfaces of coal that are exposed to the oxidizing element, oxygen. Thus in storing coal care must be observed as to the method of unloading so that breakage during this operation is at a minimum. The present coal situation has made it almost

plish this with the minimum of loss from fires, considerable study must be made of the storage problems. With the coal prices prevailing during the past year no consumer or wholesale yard can afford to handle the stored coal in a haphazard manner. If spontaneous combustion could be wholly eliminated, a remarkably large saving would be effected.

Chief Engineer of the Hartford Steam Boiler Inspection and Insurance Company

SHERWOOD F. JETER

THERE were four hundred and fifty-seven boiler explosions recorded in this country last year, an average of more than one a day. Many lives were lost and damages amounting to millions of dollars resulted. This is an appalling number when one considers that by a little human foresight and precaution practically all could have been prevented.

One of the foremost engineers engaged in the work of safeguarding the boiler plant is S. F. Jeter, chief engineer with the Hartford Steam Boiler Inspection and Insurance Company. It is his duty to see that the conditions of operation and design in the boiler room are safe. When there is an explosion in which his company is concerned, he assumes charge of the technical end of the investigation.

Mr. Jeter is a Southerner, having been born in Columbus, Ga., in 1872. After finishing his elementary education, he entered the Georgia School of Technology and graduated with the class of 1893 with a B. S. degree in mechanical engineering.

Shortly after leaving college he went to Mexico City as chief electrician of the Mexican Telephone Co. He accomplished the seemingly impossible feat of a foreigner, unacquainted with the language of the country, handling work concerned solely with its lines of communication. When he returned from Mexico a year later, he became associated with the electric railways at Atlanta, Ga., and the Hartford Steam Boiler Inspection and Insurance Co. as an inspector. Later he became master mechanic of the Pittsburgh, McKeesport & Connellsville Railway Company.

It was after leaving the railroad at Connellsville that Mr. Jeter took up the occupation which has become his life work. In 1906 he became associated with the Bigelow Company, New Haven, Conn., as a mechanical engineer. While with this company he redesigned the (English) Hornsby water-tube boiler. He resigned in 1910, determined to stick to work connected with boiler design and operation. Accordingly, he re-entered the employ of the Hartford Steam Boiler Inspection and Insurance Company as inspector. He was soon made supervising inspector and later became chief engineer.

Mr. Jeter, who has been a contributor to *Power* for a number of years, is a member of the American Society of Mechanical Engineers and of the Boiler Code Committee of that society, of which he is one of the most active members, and has done much toward the formulation of adequete rules for boiler design and operation. At present he is chairman of the Hartford Branch of the A. S. M. E.

EDITORIALS

Popular Misconceptions Regarding Super-Power Stations

VARIOUS articles that have appeared in the daily press regarding the Government Super-Power Survey have spread some misconceptions of the proposed super-power plants of this system. In the first place, What is a super-power station? Many people believe that it is some wonderful new conception, "bigger, greater and grander than ever." A prominent power-plant designer recently answered the query as follows: "What we have been building for twenty years—a new station a little bigger than the usual run." This describes the new so-called super-power stations as well as any other definition. These plants will be somewhat larger than existing plants and with newer and larger machinery more representative of the latest practice. It must be remembered, however, that the super-power plant of today will very likely be regarded as a back number ten years from now. So the name "super-power" really carries no new idea of radical change in plant design or equipment, but merely one of relative size and modern machinery.

Another impression seems to have spread abroad that all these new power plants will be located at the mines so that the railroads will be relieved of carrying the coal needed by such stations. This idea seems very attractive, and the "man on the street" wonders why the engineers have not built plants at the mines long ago. He fails to recognize some engineering and economic facts in this connection. An adequate supply of cold water for use in condensers is as great a necessity in modern high-economy steam power plants as the coal itself. Big rivers in the coal districts are not numerous. The Ohio, Allegheny, Monongahela, Susquehanna and Delaware and a few of their larger tributaries form the only large available water supplies for condenser use in the coal fields. Furthermore, it is not possible to use the same water repeatedly in a series of power houses, even along these large rivers, for eventually it would become warmed up to a point where the desired high vacuum would be unattainable. It is therefore apparent that these super-power stations must be located on the large rivers where water is available, rather than at the mine-mouths themselves. The coal will then have to be loaded in cars and hauled to these plants. In certain cases this best available water supply may be at tidewater, as at present.

The economic factor involved in power costs is probably of greatest importance in influencing plant location. The public has been led to believe that because it is quite feasible to transmit electric power over long distances in certain cases this is also the most economical system. Estimates do not always bear out this assumption when the cost of franchises, right-of-way, transmission towers and wiring, transformer stations, etc., is considered along with the constant energy loss over these long lines. Many engineers who have studied this problem have concluded that it is cheaper in many cases to haul the coal to the more advantageously situated power plants at tidewater than to generate current near the mines and to transmit it to the industrial centers along the seaboard. Nevertheless, it is most desirable that plants near the mines be developed to the greatest possible extent, though these may be limited in both size and number.

These remarks apply only to the power stations themselves and not to the immense savings that are possible by interconnecting stations in a large super-power system and thereby improving the load factors.

Engineers would do well to dispel these misconceptions on every possible occasion, for sooner or later the public will learn why the "super-power plants at the mine mouths" are not always economically possible and will reproach the engineering profession for allowing this wrong impression to be spread abroad.

Educational Courses in the Industries

EDUCATIONAL courses for power-plant operators and construction and maintenance men in industries are being given serious consideration by many companies. It has frequently been found that costly delays are caused in getting equipment back into service in case of trouble, because those making the repairs lack the information that would enable them intelligently to go about interpreting and rectifying the difficulty. Where an electric motor is started by a manual-type starter, the troubles that can occur are generally easy to diagnose. But with automatic controllers the circuits may become very complicated and the combinations of conditions that may occur to give trouble are practically unlimited, and they may be so involved as to baffle, for a time, even those well versed in the equipment affected. Consequently, in handling such equipment it is very essential that everyone who has to do with the repairs and maintenance and, in certain cases, the operator of such apparatus, should be not only familiar with it, but also well grounded in its fundamental principles.

Just what form such educational courses should take is a problem for which various solutions have been offered. However, all education has for its basic purpose the teaching of people to think for themselves, and this requires a familiarity with fundamental principles. Before one is versed in the fundamentals of any subject, one's thinking on that subject must be at best mediocre. Consequently, in any educational course for training industrial workers the first essential is teaching the fundamentals of the subject that it is desired to have the employee familiar with.

The ideal course of instruction on any subject would be one that would give to the student a training equivalent to that obtained through many years of experience. This, however, is impossible of accomplishment as many experiences have shown. Nevertheless, this does not indicate that courses of instruction in industries for employees are not successful and of vital importance in increasing efficiency. The average employee is not inefficient from a lack of experience in the practical side

of his particular vocation, but from limited knowledge of the fundamentals with which he is dealing. Therefore in a course of instruction for the electrical department employees it is not so much training one man to be a repairman, another an operator or a foreman, as it is teaching them the fundamental principles of electricity and magnetism and how to apply them to the various pieces of apparatus. After this has been done, if the man is of the right caliber, he will interpret these principles in the terms of whatever branch of the work he is following.

A wireman who has been made familiar with dynamo-electric machinery and controller circuits will be a superior employee to the one who is not and will be in a position to be promoted to departments that require this knowledge. On the other hand, an operator having this knowledge will in many cases be able to make small repairs on adjustments to the equipment he is handling, and thus prevent costly delays. Furthermore, his better understanding of the machinery that he is handling will prevent many of the abuses that equipment is often subjected to through a lack of appreciation of its limitations.

Low-Temperature Distillation of Coal in Rotating Ovens

IN THE face of a declining market in many commodities, the price of coal goes up instead of remaining constant or coming down. There may or may not be justification for this, but that is not the subject of this editorial. The condition points, however, to the seriousness of the fuel market.

Despite the great extent of our fuel resources all are agreed that our energies must be directed toward getting better results from quantities currently used than we now obtain. One more frequently meets men now who voice objection to the use of fuel oil for steam making in stationary power plants, an attitude that is not without some reason so long as the available quantity of this vital fuel appears to be less by far than we need; for as long as nations need navies and as long as ships are used, these should have first call on oil for steam making. Of course the navies of the great powers will forbid the use of oil for stationary power purposes immediately their own needs in the future are threatened. So in the future fuel oil will, in the nature of things, be regulated in its consumption far more closely than will coal.

Coal is a vital essential. Without it our civilization, as now carried on, would perish. This thought must be driven home to every man, woman and child to the end that as a nation we use it more efficiently, and that speculators and the unscrupulous have fewer opportunities to feast upon their skill.

We in America need to realize more generally that the universal use of raw coal, of the highly volatile bituminous grades especially, has in it many elements of economic waste. The byproducts of distilled coal are many, there is always a good demand for them, and new uses are frequently found.

Report comes from Germany that very material improvement has been made in the low-temperature distillation of coal by the use of the rotating oven, the oven being about the same as used in cement mills. The yield of tar is much greater than when the coal is distilled in producers, and on account of the lower temperature in the rotating furnace the valuable light hydrogens are not destroyed. The "half-coke," which is left after the tar has been distilled off, is said to lend itself well to burning on mechanical stokers, is welcomed for use in households and, moreover, it is easily briquetted.

An extensive report on the low-temperature distillation of coal in rotating ovens has been made by Doctor C. Roser, of Mülheim, and an abstract of this report will appear in an early issue.

Industry and Government Co-operating

GOVERNMENT investigations of direct interest to particular industries have often been curtailed by lack of adequate funds to continue the work. Recently the Bureau of Standards in its study of the physical constants of refrigerating materials found itself in this position and as a result has developed a new basis for co-operation which is encouraging.

The Bureau was confronted with the necessity of practically discontinuing certain parts of its work, particularly on the specific heat and the pressure-volume-temperature relations of superheated ammonia vapor. The American Society of Refrigerating Engineers was so advised and, as a result, has appointed two of the former members of the Bureau of Standards staff as research associates to continue work at the Bureau on these problems. It is expected that this arrangement will permit regular continuance of work on these important fundamentals of refrigerating technology. The results will thus be obtained promptly, and at the very minimum of cost, since the equipment and the facilities of the Bureau are afforded for the work without charge.

Doubtless there are in Washington many other investigations of great value to various branches of industry which are also suffering seriously from lack of sufficient attention or adequately trained personnel. It would seem that this new plan of affording the industries an opportunity to utilize the Government facilities should be more frequently followed. In cases where engineers find a deficiency in the Federal activities, it will be quite appropriate for them to ask themselves whether they alone are not to blame when there is this possibility of accomplishing good work by such a satisfactory co-operative arrangement.

How Much Do You Pay for Coal?

"COAL REVIEW," the organ of the National Coal Association, deduces from recent Department of Commerce figures "a cold-fact denial of the general indictment of the coal exporter on the ground that he has been reaping enormous profits."

The per ton value of American bituminous coal exported during the first seven months of 1920 was, according to this article, $7.29, including freight to the spot where the coal passes out of the country.

If this is all that the sellers of coal to foreign customers have been getting they ought not to be hanged.

But why was the United States Shipping Board compelled to pay eighteen to twenty dollars per ton?

Why were many of our industries compelled to pay much more than foreign customers?

How does this price compare with what YOU have been paying?

CORRESPONDENCE

Where Should the Beginner Start?

The possible results of an engine accident and a boiler accident cannot be compared. It is rare that an engine accident does great damage, and save in the case of a bursting flywheel it is usually confined to the engine room and the man in charge. A boiler explosion will probably wreck the building or buildings and may kill or injure many.

The responsibility resting on a fireman is far greater than that on the man caring for the engine. The general idea is that the man in the engine room is looking after the man in the fireroom, and that it is up to him to see that there is no low water or too high steam is true to a certain extent, but everybody knows that the care of the boiler is almost always given over to the fireman just as soon as the engineer believes that he is competent.

The engineer will stroll into the boiler room now and then to see if it looks nice and neat; if it does, he is usually satisfied. The man with the shovel is the first to see if any of the tubes are leaking and if anything about the boiler is not right, and he gets such important information first. He also has a better chance to study the effect of his firing and water-feed regulation than the engineer. The engineer knows all the regular noises of his engine room. If the note alters, he gets right after the reason if he is worthy of his job. The engineer has some warning as to possible trouble in the engine room, but the fireman generally has no intimation whatever of a serious accident.

The engineer takes his indicator diagrams, sets the valves to suit working conditions and at intervals takes diagrams to see if the valves remain adjusted, and that is about all he directly does in keeping track of the plant economy.

The fireman has to contend with weather and varying coal conditions. He has to keep the boiler clean both inside and out. Thanks to the electric light, a fireman can inspect the inside of a boiler thoroughly, without having his lungs filled with lampblack and oil as in the olden days.

Some will say that a fireman is not the man to inspect a boiler. He should be, and if he is not competent to do so, he should not be rated as a first-class fireman. The fact that the fireman is bound to be rather dirty most of the time has given rise to the idea that his brains are small.

There is no doubt that the hard physical work of firing makes a man desirous of an easier job in the engine room, so he leaves his position of responsibility in the boiler room for the engine-room chair and thinks he has gone up.

I fear that Mr. Lane's idea of starting the fireman in the engine room would not work—not because it is illogical, but because the opinion exists that the direction of the fireroom is downward and not upward in the mechanical social scale. Although we are supposed not to have any class distinction, the engineering world, taking it as a whole, will say that the engine room stands higher in the scale of mechanical workers than the fireroom, and to controvert that sentiment is a hard job.

Of course there are engineers in charge of power plants who look after the boilers and engines with equal care, some giving even more care to the boiler end. Such men train up good firemen, who are stolen away by others. The fireman who is employed only to open furnace doors, shovel in coal and close the doors again and start up the feed pump full tilt when he sees the water lower than usual, does not command high pay.

Saluda, N. C. W. D. FORBES.

Battery Used To Get Alternator and Exciter Into Service

In the plant of which the figure shows a general layout there is one 1,000-kva. and one 2,000-kva. engine-driven 440-volt alternator, which can be excited either from a motor-generator set or an engine-driven exciter. Additional power is obtained from a utility company through two 1,200-kva. 26,000- to 440-volt and two 750-kva. 26,000- to 2,300-volt transformer banks. We also have three substations equipped with 2,300- to 440-volt transformers. One of these substations supplies current to two battery-charging sets, the direct-current side of each furnishing about 120 amperes at 110 volts.

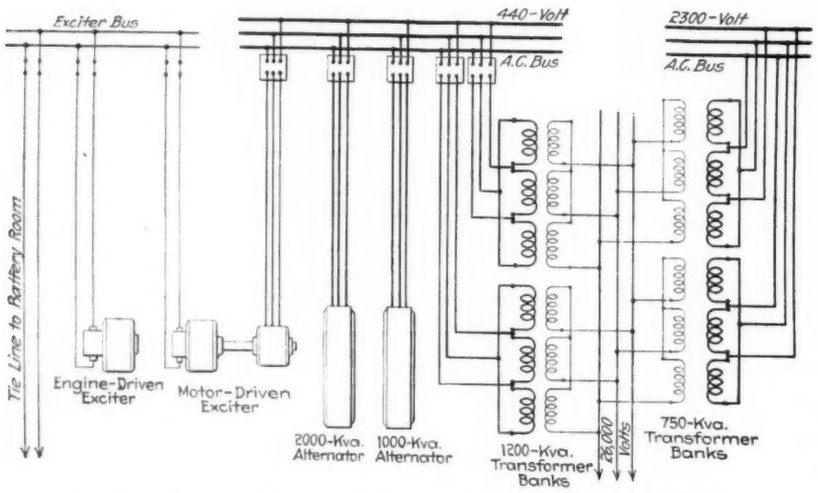
Formerly all direct-current load in the factory was supplied from the exciter bus in the engine room, but recently a tie-line was installed and this load was transferred to one of the battery charging sets, since the other set could readily take care of all the battery load. This left the exciters to take care of the engine load alone. It frequently happened during thunderstorms that the incoming high-voltage line would be out of service for some time, and every time this occurred the motor-driven exciter would fall out of step and stop. Then the steam-driven exciter would have to be started and all the load possible was carried on the generators until the outside source came back into service.

The steam-driven exciter was under repair for several days when a thunderstorm occurred just at a time when

the cupolas at the foundry were running full blast. The high-voltage line went out, shutting down all substations, of course, and also "dropping" the motor exciter, leaving the plant virtually without power. After some deliberation it was decided to send current from the batteries at the battery room over the tie-line to the engine room, 1,000 ft. away. When the fields were excited, the direct-current voltage dropped to about 60 volts, but we got sufficient emf. from the alternator to start the motor exciter. The direct-current side of the exciter was then paralleled with the battery, after which no trouble was experienced in getting the voltage up to 110 on the exciter bus. This, of course, gave full voltage on the alternator, and it did not take long to get the foundry back to work again, and two 72-in. cupolas were saved from dropping their bottoms.

ROBERT HOFSTETTER.

Kenosha, Wis.



SCHEMATIC DIAGRAM OF POWER-PLANT EQUIPMENT LAYOUT

Fuel Waste Causes Failure of Central Heating Station

The communication by William M. McNeill, page 476 of the Sept. 21 issue of *Power*, will, I think, interest many engineers, inasmuch as it will call to mind plants that they have run under conditions similar to those depicted by Mr. McNeill, which are by no means confined to the past. Many power plants are still operating under equally uneconomical conditions.

At one time I was thoroughly familiar with a plant operated under the direction of a committee appointed by the city council. The plant was run as cheaply as possible, everything purchased was of the cheapest character, and nothing was purchased until it was necessary either to do so or shut down. It was the practice to line the boiler furnaces with ordinary red brick, which would soon crack and crumble and fill the combustion chamber with broken pieces.

The water used was exceedingly scaly, and a hard lime substance formed on the tubes and heads of the boilers, besides a large quantity of loose scales, which accumulated so fast that it was necessary to wash out each boiler once a week. They would not purchase a compound to counteract the scale, hence the spaces between the tubes next to the rear head were filled solid, with the result that many of the tubes were leaking. This leakage mingled with the soot baked on the tubes, and in some cases almost filled the openings to them at the rear end, which, of course, obstructed the draft. In many cases the tube ends that were beaded over the tube sheets were burned, and it was necessary to replace tubes every few weeks.

The outsides of the boiler settings were almost as bad as the insides, and in case the fireman should choke his damper very close after fuel had been placed in the fire, smoke would issue from almost countless openings, showing that the leakage of excess air in the furnace was exceedingly great.

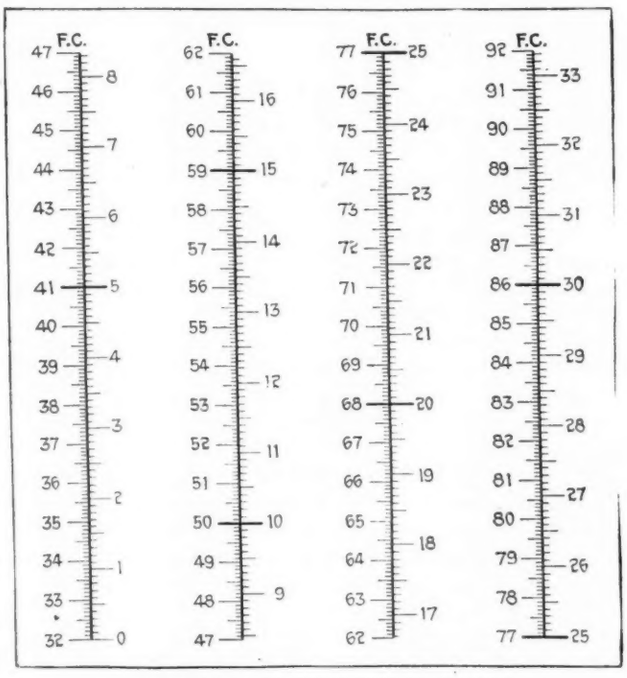
The three generators were equipped with the old type of copper brushes, each machine requiring twelve, and the committee used to buy them in half-dozen lots.

Other matters pertaining to operation were carried along in the same slipshod way, and it is doubtful if there was ever a competent engineer in charge of the plant. Eventually, it passed into the hands of a private company, which, after reconstructing much of the machinery equipment, has operated it in an efficient manner.

Chicago, Ill. E. T. BONNAR.

Thermometer Conversion Chart

It is not always convenient to have handy a conversion table of thermometer readings from degrees Fahrenheit to degrees Centigrade, therefore R. E. Gould, of the Bureau of Standards, has arranged in convenient form the accompanying chart for changing Fahrenheit to Centigrade readings ranging from 32 deg. F. and 0 C. to 92 deg. F. and 33.3 deg. C.

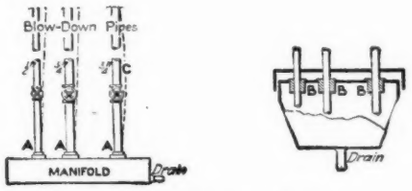


THERMOMETER CONVERSION CHART

Washington, D. C. R. MCBRIDE.

Improvement on Water-Column Blowdowns

In the original installation the water-column blowdown pipes of my plant were piped into a manifold without any slip joints, as at *A*. When the columns were blown down, the pipe would expand as represented by the dotted line *C* in the illustration. In order to



OLD AND NEW MANIFOLDS

eliminate this trouble, an expansion chamber was installed in which all expansion is taken up by the clearance on the inside. Brass sleeve *B* prevents water coming out of the expansion chamber around the pipes.

Philadelphia, Pa. A. S. BARKER.

Mechanical Stokers and Their Operation

Regarding the article on "Mechanical Stokers and Their Operation," published in the Sept. 7 issue of *Power*, I wish to state that the author is not quite accurate in his description of one of the stokers shown, in that the single-retort type is referred to in the text matter, whereas the illustration, Fig. 4, shows a multiple-retort stoker of new design. The stoker shown in Fig. 4 of the article properly belongs in the same classification with the multiple-retort gravity-feed stoker.

R. SANFORD RILEY, President,
Worcester, Mass. Sanford Riley Stoker Co.

Condenser Water in Low-Pressure Cylinder

Some time ago it was my privilege to see a near wreck of a vertical compound engine. It had been running for perhaps an hour without load, while being given a tryout. When it was decided that the test was satisfactory, the watch engineer closed the throttle and then stopped the air pump, opening a small vacuum breaker afterward.

In perhaps fifteen seconds there were at least six or eight distinct crashes and it seemed that something had let go. The chief engineer shouted to the watch engineer to start the air pump. He hastily opened the throttle on the air pump, and no more thuds occurred.

"For heaven's sake man, do you stop the air pump every time as you just did?" asked the chief.

"Sure," answered the watch engineer. "What do you suppose that noise was?"

"That was water between the piston and head," answered the chief, "and in a vertical engine it is a mighty serious thing. The head generally lets go in a horizontal engine, but the frame breaks in a vertical engine under such conditions."

"How can a vertical engine with the cylinders thirty feet above the condenser take water?" was the next question, and the chief explained it as follows:

"We know that theoretically the atmosphere will balance a column of water thirty-four feet high. In practice, a mighty good piston pump with small friction losses will draft water thirty feet. Perhaps this sounds a little bit bookish, but nevertheless I've seen it done. The weight of a gallon of water is 8⅓ lb. Its cubical contents are 231 cu.in. If the atmosphere is 14.7 lb. per sq.in. at sea level, then $\frac{\frac{14.7}{8\frac{1}{3}} \times 231}{12} = 33.9$ ft."

"What about the low-pressure cylinder getting water?" asked the watch engineer.

"If you will just pay attention, I'll tell you how you just got that dose of water," said the chief as he sketched a pump. Fig. 1, drafting water thirty feet. Fig. 2 shows the same pump drafting water fifty feet.

"No use—it can't be done," said the watch engineer.

"It can be done if a hole is made in the pipe at the water line as at *A*," replied the chief. "If you suck in air at *A*, it breaks the vacuum to a great extent, of course, but the water and air will mix and the mixture will go up the pipe like smoke up a stack."

"How about thirty-three feet doing the balancing now?" asked the watch engineer. "The mixture doesn't weigh 8⅓ lb. to the gallon now, it weighs only about 3½ lb.," was the reply. "Using the same formula,

$$\frac{\frac{14.7}{3.5} \times 231}{12} = 80 \text{ ft.}$$

"Now, if you are satisfied that a mixture of water and air can be lifted over thirty-four feet, what is to hinder a low-pressure cylinder on a vertical engine from lifting water in a mixture thirty feet or even forty feet?

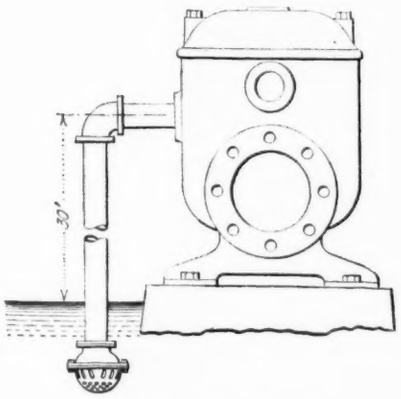


FIG. 1. PUMP WITH 30-FT. LIFT

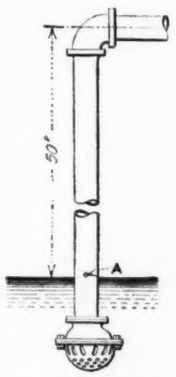


FIG. 2. WITH 50-FT. LIFT

When you just tried out your engine, you had no load. The receiver gage showed about two or three pounds with the throttle wide open. When you started up, the vacuum didn't show very good, did it? No, and you had to close the cone almost tight on the injection. When you shut off the throttle, the vacuum went back through the receiver like a shot.

"Stopping the pump didn't stop the vacuum in the low-pressure cylinder but in the condenser. The vacuum breaker acted like the hole in the pipe and up went the mixture. Deliberately stopping an air pump with the throttle shut on the engine but the engine still running is the most foolhardy trick I know of. Of course, an extra-large vacuum breaker is a remedy, but few air pumps or condensers are so equipped."

New York City. C. W. PETERS.

Condenser-Tube and Cast-Iron Shell Disintegration

My attention was attracted to an article appearing in the Aug. 17 issue of *Power* entitled "Salt Water Leakage in Condensers," by Mr. Overend, in which he related his experience with some surface condenser and pump installations where the cast-iron shell was showing signs of disintegration, or rather, becoming soft and spongy and presenting what is commonly termed a change to graphite condition.

In an article that appeared in the issue of April 13, page 588, entitled "Prolonging the Life of Condenser Tubes," it will be noted that I assigned, as the reason for the rapid disintegration of bimetallic condenser tubes, the dissimilarity of the metallic groups entering into condenser assembly.

It was pointed out in this article that a difference of potential will be established with proper electrolyte conditions existing between the copper- or brass-alloy tube and the cast-iron shell.

The tube, always being electro-positive, is the element that suffers the most rapid metallic disintegration, and having observed many conditions of condenser-tube disintegration, I have noticed that in practically every instance where the tubes were subject to decomposition the shell of the condenser also presented signs of change in the state of iron, as outlined by Mr. Overend. I had long been of the opinion that the decomposition of the iron shell was closely associated with the disintegration of the tube, or in other words, that the tube disintegration produced a condition that would render the shell or cast iron also subject to decomposition. I hesitated, however, to advance this theory until such time as I was able to present some confirming results of experimentation in this line; and with this in mind, I have had constructed three groups of metals analogous in every respect to present surface-condenser assembly:

Group No. 1—Being two cast-iron plates permanently fixed to a standard section of condenser-tube sheet, bronze and properly drilled with standard clearance and provided with standard condenser ferrules. Assembly No. 1 being packed on one end with corset lace and having the tube expanded or rolled on the other end.

Group No. 2—Having identical cast-iron sides and identical tube sheet, but packed in the regular manner on both ends with corset lace.

Group No. 3—Being identical with assembly No. 2, but instead of being packed with corset lace, the section of tube is bonded at both ends with flexible metallic packing rings.

The 8-in. sections of tubes used for this experiment were cut from the same piece of standard $\frac{3}{4}$-in. condenser tubing as supplied by one of the large manufacturers.

These three assemblies were immersed simultaneously in a glass vat filled with distilled water to which had been added enough chemically pure salt to bring it to the density of sea water.

Two hours after immersion the water in the vat became muddy and indicated that a condition of corrosion was occurring, and after being immersed about one week, the section of tube employed in assembly No. 1 presented visible signs of attack, and in this assembly disintegration of the tube appears most rapid.

Assembly No. 2, in which the section of tube is packed on both ends with corset lace, and, therefore, being insulated, shows visible signs of attack, or disassociation of the metal, but not nearly so rapid as is the case with No. 1.

In both these assemblies an examination after three weeks' immersion shows very plainly that the cast-iron sides, which represent the shell, are subject to decomposition. There is a black deposit forming uniformly over the cast-iron plates of these two assemblies, which would indicate that the hydrogen that is evolved at the cathode is in some manner responsible for this condition.

Assembly No. 3, or the group on which the tube is bonded on both ends, presents no such appearance. The surfaces of the cast-iron plates are as bright as they were when they left the planer, and the tube employed in this assembly shows no change, the surface of the bimetallic tube remaining just as bright as when it was placed in the solution.

Placing a millivolt meter across the groups, we measure a slight difference of potential between the brass tube and the cast-iron plate of assembly No. 1. On assembly No. 2 the meter registers permanently 10 millivolts, but if the solution is slightly agitated or set in motion, as occurs when the water is being circulated or is in motion in the condenser, the difference of potential immediately rises from 10 millivolts to between 15 and 50 millivolts.

This difference can be easily accounted for by the fact that the cast iron develops a state of polarization when there is no agitation of the liquid; in other words, the hydrogen that is evolved, clings to the cast-iron surface in a film that is insulating in character and greatly increases the resistance, but the moment agitation is produced this film is broken up so that the maximum difference of potential due to the dissimilarity of the group may become established.

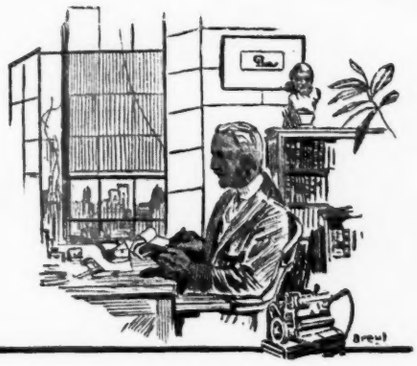
Connecting the millivolt meter between the tube and the cast-iron sides of assembly No. 3, in which the tube is bonded with the flexible metallic rings, there is positively no difference of potential indicated between this assembly, and this, in my opinion, is the reason why we do not get the signs of disintegration in that assembly. And likewise, the elimination of the bond between the metallic groups as cited in assembly No. 1 and assembly No. 2, is the reason we do get the signs of disintegration as outlined and occurring in those two assemblies.

I believe this is a subject in which engineers and manufacturers should become acutely interested, for the matter of tube disintegration and also the matter of cast iron where employed in condensers, pump casings, etc., are of great importance, and it is my firm conviction that these bad effects will be overcome only by the proper assembly of any bimetallic groups that enter into this apparatus in such a manner that the differences of potential that are bound to occur with these dissimilar groups will not produce the electrolytic breaking down of either the bi-metal or the disassociation of the cast iron.

It is hoped that interest may be aroused to the end that manufacturers will begin to look more closely into this theory and develop their own experiments to confirm or deny.

JULIUS N. WALTON,
Eastern Manager, Crane Packing Co.
New York City.

INQUIRIES OF GENERAL INTEREST



Lap of Steam Valve on Long-Range Corliss Cutoff—How much lap has the steam valve of a long-range double-eccentric Corliss engine when the wristplate is in mid-position? J. B.

When the wristplate is in midposition, the steam valve must have negative lap—that is, must be part way open. The lead is delayed by turning the eccentric backward from the 90-degree position, so the cutoff may act after the piston has completed one-half of its stroke.

Smoky Exhaust of High-Compression Oil Engine—What would cause a two-cycle high-compression hot-cup oil engine to have a smoky exhaust and preignition? C. M.

Both troubles result from imperfect combustion. With a good quality of oil, imperfect combustion and the resulting smoky exhaust may be due to excessive water cooling of the cylinder head and hot cup. So called preignition is pre-explosion of hydrocarbonaceous material that has been left over by imperfect combustion of a preceding stroke.

Reduction of B.t.u. per Pound to Calories per Long Ton—What would be the number of calories per ton of 2,240 lb. of coal containing 11,500 B.t.u. per pound? B. H. C.

The gram-calorie, or small calorie, is the heat required to raise the temperature of 1 gram of pure water from 15 to 16 deg. C. The kilogram-calorie, or large calorie, which is equal to 1,000 gram-calories, is the one generally employed by engineers and is equal to 3.968 B.t.u.; that is, 1 B.t.u. = 0.252 kilogram-calorie. Hence a long ton, or 2,240 lb., of coal containing 11,500 B.t.u. per pound would contain $2,240 \times 11,500 \times 0.252 = 6,491,520$ kilogram-calories.

Injury to Indicator from Use on Ammonia Compressor—Is an ordinary nickeled brass indicator damaged from use on an ammonia compressor? E. R. B.

There may be injury to an indicator from corrosion of brass valves or indicator cocks or three-ways left on the connections. Indicators and connections that are allowed to remain attached to the compressor cylinder for long periods of time should be made of iron or steel. But no serious damage will be done to a brass indicator when left connected only long enough to obtain diagrams, provided the instrument is cleaned with the same care that an indicator should receive after use on a steam engine.

Inexactness of Relations of Viscosimeter Tests—What are the respective relations of tests of the viscosity of oil obtained by Saybolt, Engler, Redwood and Tagliabue viscosimeters, and how are they obtained? H. S.

In each of the instruments the viscosity value is based upon the number of seconds of time taken by a set amount of oil to flow through an orifice that has been calibrated for the time required for the orifice to discharge the same quantity of water. There is no generally accepted tests for viscosity as various types of instruments are used, and the results with different instruments will often vary considerably. None of the types have orifices of exactly the same size. Unless the names of the designer and maker of the instrument used and the amount and temperature of oil used are stated, the results are almost meaningless. Therefore it is impossible to translate the readings of one instrument to that of another with any accuracy.

Trouble Pumping Hot Water Under Head—What causes trouble pumping hot water when the water flows by gravity to the pump? H. F. J.

If the piston displacement of the pump is faster than flow of the suction water can supply, there will be cavitation in the pump cylinder and suction passages to the pump in which the pressure becomes so reduced that the hot water bursts into steam of pressure corresponding to the temperature and the pump cylinder thereby becomes steambound. The remedy is to stop the pump, open all the drain valves on the water end of the pump and leave them open until the water flows free of vapor, and then start and run the pump slowly.

Pressure for Operating Heating Boiler—The boiler used for heating our building is operated at 85 lb. pressure, and the steam is supplied through a reducing valve at 10 lb. pressure. Would it not be more economical to operate the boiler at 10 lb. pressure and supply the steam direct. C. P. R.

There is neither loss nor gain of heat from passing steam through a reducing valve, excepting the small loss due to radiation, and therefore no difference in the economy of steam supplied to the heating apparatus. There is an advantage, however, in carrying a higher boiler pressure and supplying the heating apparatus at reduced pressure to better meet variations in the demands of the heating apparatus and, where necessary, for operation of a pump for boiler feeding or for handling the returns; but where these are unnecessary and there is no demand for high-pressure steam for other operations, it is safer and, on that account, better to operate a heating boiler at no higher pressure than necessary to supply the heating apparatus.

Size of Steam Outlets for Power Boilers—What is the method of determining the size of main steam outlets for boilers? W. G. S.

The minimum size of steam outlet suitable for a boiler is governed by the size of steam-pipe connection likely to be selected with reference to the permissible drop in pressure for maintaining the desired rate of flow of steam under the conditions of use. For power boilers the requirements usually can be met commercially by having the boiler outlet of diameter in inches equal to the square root of one-fourth of the boiler horsepower. Accordingly, the steam outlet appropriate for a 60-hp. boiler would be $\sqrt{60 \div 4} = 3.87$, or commercially, 4-in. diameter pipe size; for a 150-hp. boiler, $\sqrt{150 \div 4} = 6.1$ or 6-in. diameter pipe size; and for 300 hp., $\sqrt{300 \div 4} = 8.6$, or, commercially, 8-in. pipe size. With increasing use of higher pressures there is a tendency to use smaller piping and boiler outlets, because with steam of greater density less drop of pressure is needed to sustain the required flow of steam, and also because the drop for the necessary flow is a smaller percentage of pressure required at the point of delivery.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Association of Iron and Steel Electrical Engineers' Annual Convention

THE fourteenth annual convention of the Association of Iron and Steel Electrical Engineers, held in the Hotel Pennsylvania, New York City, Sept. 20-24, proved to be one of the most successful in the history of the association, both in technical value and in entertainment features. Among the important features was the exhibition of equipment used in steel mills, seventy-two manufacturing companies being represented.

At 10:30 Monday morning the convention was opened with a business session at which E. S. Jefferies, Elec. Eng., Steel Company of Canada, Hamilton, Ont., was elected president of the association for the year 1921. Other officers elected were: First vice-president, W. S. Hall, Elec. Eng., South Works, Illinois Steel Co., South Chicago, Ill.; second vice-president, C. E. Bedell, Elec. Supt., Wheeling Steel and Iron Co., Wheeling, W. Va.; treasurer, James Farrington, Elec. Supt., La Belle Iron Works, Steubenville, Ohio; secretary, John F. Kelley (re-elected) 513 Empire Bldg., Pittsburgh, Pa.; directors, Gordon Fox, Elec. Eng., American Steel and Tube Co., Mark Plant, Indiana Harbor, Ind.; L. F. Galbreath, Elec. Eng., West Penn Steel Co., Brackenridge, Pa.; S. L. Henderson, Elec. Supt., American Steel and Wire Co., Cleveland, Ohio, and W. C. Suppler, Elec. Supt., Tennessee Coal, Iron and Railroad Co., Ensley, Ala.

E. S. JEFFERIES,
President-Elect, Association of Iron and Steel Electrical Engineers

On Monday afternoon the first technical session was held, at which two papers were presented: "Practical Education of Steel Mill Electricians," by B. A. Cornwell, chairman Educational Committee. It has been realized that there is a pressing need for some course of instructions for repair men on electrical equipment in steel mills. Up to the present time there is apparently no textbook that meets these needs, therefore the educational committee co-operating with the electrical manufacturers are preparing such a book. In the papers are given sample pages intended for this book. The discussion brought out considerable difference of opinion as to what a course of this kind should consist of and how it should be given, the point being raised that a crane operator should be given different instructions from those of a wireman or an armature winder, and that there should be different grades of instructions for different classes of employees. For example, a gang foreman should have a higher training than that given the men under him. It was the general opinion that a simple, easily read textbook would be extremely valuable in giving such a course of instructions.

A second paper presented at Monday afternoon's session was "Relation of Standardization in Electrical Equipment to Safety," by Walter Greenwood, the point being made that standardization reduces accident hazards. The author said: "In the case of standards for cranes they include quality, convenience, etc., also uniform arrangement of controlling parts should be included. Individually considered, hazard

MEMBERS OF THE ASSOCIATION OF IRON AND STEEL ELECTICAL ENGINEERS AND THEIR FRIENDS

is reduced by quality in that breakage cannot occur unless capacity is exceeded; capacity cannot be overtaxed where control is properly regulated. Uniform arrangement of controlling parts, manually operated, reduces hazard by reducing liability of operating the wrong movement. Convenience reduces hazard by making situations and parts easily accessible. Interchangeability reduces hazard and is classified with convenience, but going back from the operating end, interchangeability simplifies construction, and through efficiency in construction of interchangeable parts hazard is again reduced. Collectively considered, efficiency in maintenance reduces hazard. The same reasoning applies with equal force to all apparatus employed in producing commodities whether in the iron and steel industry or others.

Tuesday's Technical Session

On Tuesday only one technical session was held at which two papers were presented. "Power Transmission in Industrial Plants," by D. M. Petty, discusses this problem from the high-voltage sides only, low-voltage distribution from transforming station not being included. Power supply is divided into four sources—gas engines, steam turbines, reciprocating steam engines and public utility systems—each of which presents a somewhat different problem. The question of bus structures, transmission systems, electrical schemes of transmission, loop feeders, overhead versus underground transmission are gone into and the conclusion is drawn that the ideal transmission system is one "which transmits the necessary power to the producing departments of a plant at the lowest cost, with the least interruption and with the smallest hazard to the lives not only of those skilled in the art of handling electrical apparatus, but also of those entirely ignorant of its dangers."

In discussing the papers, the point was raised that with underground construction more copper is required on account of heating. However, as it is desirable to reduce the line losses to the lowest possible value, it is evident that the extra copper used is valuable in reducing the line losses.

"Underground Transmission," by A. L. Freret, was the second paper presented at Tuesday morning's session. In this paper three methods of installing underground conductors are discussed; namely, in a tunnel, in ducts, or by burying directly in the earth.

A paper, "Some Considerations in the Determination of Auxiliary Drives," by Gordon Fox, was presented and discussed at Wednesday morning's session. This paper sets forth certain factors influencing the selection and application of motors and control and considers the relation of the motor to the machine and work and suggests methods of procedure in the selection and application of motors to varied duties.

It was evident from the discussion of the paper that the tendency was toward using higher-speed motors and high gear ratios. The opinion was expressed that it was wrong engineering to connect the motor as directly as possible, and that the large slow-speed open-type motor is an abomination. Also some objection was raised to the forced ventilation of motors, since the motor might be cool on the outside, but hot-spot might exist in the winding, which would tend to increase the upkeep. However, there were those who did not object to the forced ventilation of motors.

Report of Electrical Development Committee

Of special interest is the Electrical Development Committee report, presented by the committee's chairman, E. S. Jefferies, at the Wednesday morning meeting. In this report an attempt has been made to cover electrical development as pertaining to steel mills for the last five years. It is stated that undoubtedly the most important electrical application has been the adoption of the Ilgner system of drive to reversing mills, the sentiment regarding electrically driven reversing mills having changed entirely since the first few were installed. A tabulation given shows that there are 34 of these equipments in use and 8 being built, requiring motors ranging in size up to 22,000 hp. maximum rating. The report calls attention to the fact that until recently all reversing drives ordered were for new installations only, while at present there are being built or installed four equipments to replace steam engines. A list of 76 alternating-current adjustable-speed sets that are in operation driving main rolls ranging in capacity up to 3,000 hp. is part of the report. This development has practically fallen within the last five years.

K. A. Pauly presented his paper, "The Reversing Electric Mill Considered from the Standpoint of Tonnage," at the Wednesday afternoon session. Until recently the question of tonnage in electrically driven reversing mills has been subordinated to systems of control having as their object the protection of the electrical equipment from peak loads. However, within the last year a number of electrically driven reversing mills have been going after tonnage records, and these have proved that they can produce tonnage equal to or greater than steam-driven mills.

In the discussion on this paper a monthly output of

AS GUESTS OF THE UNITED STATES STEEL CORPORATION AT BEAR MOUNTAIN, NEW YORK

57,130 tons was given for one electrically driven reversing mill which it was estimated would roll 60,000 to 70,000 tons when it reaches its maximum. It was pointed out that the efficiency of the motor was secondary to the efficiency of producing steel. An interesting feature of the discussion was the question of shunt-wound versus compound-wound motors, and from the points brought out it would appear that either type could be developed to produce equal tonnage records.

From the point of view of the power-house man one of the most interesting papers was "Some Economic Considerations in Design of Power Plants for Steel Mills," by T. E. Keating, presented at the Thursday morning session. An abstract of the paper and discussion will appear in an early issue.

A paper presented by R. H. Keil, at Thursday morning's session, "Current-Limit Reactance," emphasized how important the question of electrical-power-equipment protection had become in many of the large steel mills, where the power plant had reached proportions that compared with many central stations. The various schemes of connecting current-limiting reactors into the circuit are gone into and the results obtained from each method enumerated.

One of the most comprehensive reports presented was that of the Electric Furnace Committee, read by the committee chairman, E. T. Moore, at Thursday afternoon's session. This report covers 28 pages and should prove of exceptional value to those interested in the subject.

Friday morning's session was the closing technical meeting. At this meeting the Standardization Committee report was presented. This report embraces the sub-committee's reports on motors, cranes, controllers and illumination. In the discussion on this report the necessity of a standard specification for purchasing cranes was emphasized, but how far standardization should be carried in this direction was a question that apparently will require considerable more consideration for its solution. It was pointed out that if the association did not produce standard specifications for cranes during the coming year the United States Government would.

An entertainment and cotillon ball was given in the grand ballroom of the hotel Monday evening. On Tuesday afternoon the members and their friends were taken up the Hudson River to Bear Mountain on the Hudson River Daylight Line Steamer "Robert Fulton," as guests of the United States Steel Corporation. Dinner was served at the Bear Mountain Inn. On Wednesday evening the annual banquet was held in the grand ballroom of the hotel, at which Dr. Thomas Darlington was toastmaster. W. A. Berresford, president of the American Institution of Electrical Engineers, in addressing the gathering, outlined the new developments in engineering associations and pointed out how these could help the members of the Association of Iron and Steel Electrical Engineers. He urged affiliation with the Federated American Engineering Societies, Engineering Foundation, American Engineering Standards Committee, and National Research Council. F. B. Jewett, chief engineer, research laboratory, Western Electric Co., told about the development of the telephone during the last fifteen years. John R. Freeman, past president, American Society of Mechanical Engineers, who has recently returned from an extended trip in China, investigating the future possibilities of developing that country's waterways, gave an illustrated talk on the waterways of China. A. C. Dinkey, president, Midvale Steel Co., made a short address on the work of the association.

Interpretations of the A.S.M.E. Boiler Code

THE following answers to requests for interpretations of the Boiler Code have been prepared by the Boiler Code Committee, and approved by the Council, of the American Society of Mechanical Engineers. The formal inquiry and reply are given, together with explanatory references to the Code and illustrations where necessary for a better understanding of the interpretations as issued:

Case No. 269 (Re-opened)—Inquiry: If under the provision made in Par. 212*c* of the Boiler Code advantage is taken of the opportunity to increase the pitch of the staying for a cylindrical furnace, is it to be assumed that a portion of the increased load on the staybolt is to be supported by the resistance of the outer cylindrical shell to collapse, or must the staybolt be designed to carry the full load upon the stayed area of the furnace sheet?

The inquiry refers to a cylindrical surface subject to external pressure, such as the furnace in a vertical boiler. Par. 212*c* provides that the maximum allowable pitch of the stays may be computed by the following formula:

$$p_1 = p\sqrt{\frac{PR}{PR - 250T}}$$

where p_1 = equivalent pitch for a cylindrical surface, p = maximum pitch for a flat surface as specified in Par. 199, P = maximum allowable working pressure in pounds per square inch, R = internal radius of furnace in inches and T = thickness of plate in sixteenths of an inch.

Par. 199 gives the following formula for flat stayed surfaces:

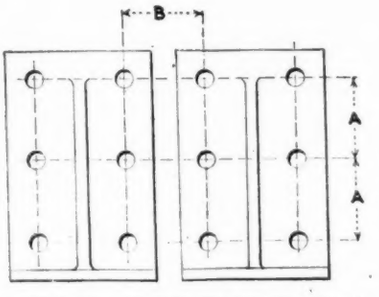
$$P = C \times \frac{T^2}{p^2}$$

where P = maximum allowable working pressure in pounds per square inch, T = thickness of plate in sixteenths of an inch, p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, in inches, and C = a constant having different values for different thicknesses of plate and different types of staybolt heads.

Reply: The special provision made in Par. 212*c* for increased pitch is made possible by the additional strength afforded by the convexing of the plate. It is permissible under this rule to increase the spacing of the staybolts to p, in the formula, whereas the required cross-sectional area of the staybolts should be based on p.

In other words, the shape of the furnace structure is such that it would support a *part* of the load without any stays. Therefore the load on each individual stay is not as great as the increased pitch, and it may be assumed that it carries a load equivalent to that indicated by the smaller pitch that would be required if the plate were flat.

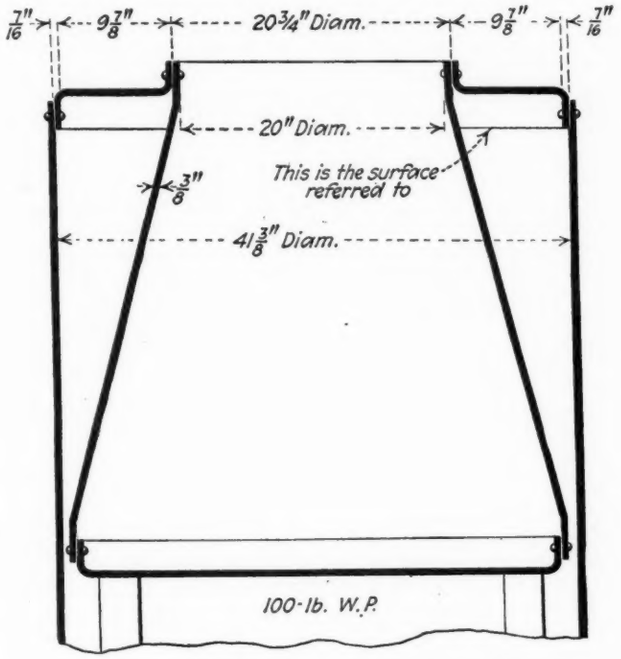
Case No. 307—Inquiry: Is it permissible to so locate the supporting lugs on horizontal return-tubular boilers where more than four lugs are required and under Par. 323 of the Code, must be set in pairs, that those in each pair come close together, or must the horizontal distance between the center lines of rivets attaching the adjacement lugs to the shell be at least equal to the vertical spacing of rivets that is required for lug attachments in Par. 323, as shown in the illustration?



CASE 307. RIVET SPACING WHEN SUPPORTING LUGS ARE SET IN PAIRS

In other words must distance *B* be at least equal to distance *A*? Par. 323 provides that horizontal return-tubular boilers shall be supported from lugs. The second sentence of this paragraph requires that no more than two of the rivets come in the same longitudinal line on each lug. The inquiry hinges on the weakening of the shell due to rivet holes if the two lugs of a pair are set too close together.

Reply: There is no requirement of the Code specifying the distance apart of the lugs forming pairs as required by the last sentence of Par. 323. It is the opinion of the committee, however, that in locating lugs in pairs on the shells of horizontal return-tubular boilers, it will be in conformity with the spirit of the second sentence of Par. 323 if the lugs of the pair are so spaced that the horizontal distance between the centers of the rivets which come nearest the adjacent edges of the lugs is at least 6 in. and not more than 12 in.



CASE 308. SUBMERGED-TYPE VERTICAL BOILER

Case No. 308—Inquiry: Under what rules in the Boiler Code should the top head of a vertical submerged-tube type of fire-tube boiler, such as shown in the illustration, be calculated to determine whether or not it requires bracing?

Reply: There is no rule in the Code specifically applying to such construction. However, in Par. 216, an allowance is made for surfaces located between tubes and shells. It is the opinion of the committee that it would be entirely safe to permit similar allowances in this case; that is, the distance between supported joints could be made 3 in. greater than the permissible spacing of staybolts for the corresponding plate thickness and pressure given in Table 4.

Table 4 in the Code gives the maximum allowable pitch in inches, of screwed staybolts, ends riveted over. These values are computed by means of the formula of Par. 199.

Case No. 309—Inquiry: Is it necessary to furnish test reports of the steel used in the tubes or flues of special type boilers which are formed of 18-in. lap-welded steel tubing, 15 ft. long, where the wall thickness is ½ in. and the weld meets the requirements of Par. 186?

Par. 186 refers to welded joints and provides that the ultimate strength of such a joint which has been properly welded by the forging process shall be taken as 28,500 lb. per sq.in. with steel plates having a range of 45,000 to 55,000 lb. per sq.in.

Reply: It is the opinion of the committee that the material used in the manufacture of lap-welded low-carbon steel tubing should meet the stipulations prescribed in Pars. 23 to 39 inclusive of the Code, which will make it necessary to furnish mill test reports of the material.

Pars. 23 to 39 inclusive contain the specifications for boiler-plate steel and provide for tests of specimens of the material with reports and marking of the plates with the strength, etc.

Case No. 311—Inquiry: Is it necessary under Par. 188 of the Boiler Code to use butt-strap joints in the construction of very small drums, say 10 or 12 in. in diameter, for pressures exceeding 100 lb. per sq.in? Such construction does not appear to be practicable for such small drums and neck pieces sometimes used to connect drums or shells.

Par. 188 provides that the longitudinal joints of a shell or drum which does not exceed 36 in. in diameter, may be of lap-riveted construction, but that the maximum allowable working pressure shall not exceed 100 lb. per sq.in.

Reply: Lap-riveted construction is prohibited by the Code rules, but it is the opinion of the committee that this should cause no hardship, as lap-welded or seamless pipe or tubes could be used provided such tubes or pipes are constructed from material which in its initial form of plate or skelp conforms to one or the other of the specifications for open-hearth steel given in the Boiler Code. No test would be required on the completed tube. (See Case No. 255.) Case No. 255 and Case. No. 218, to which it refers, provide that the materials of which headers and manifolds are made shall conform to one or the other of the specifications for wrought steel, but the reply to Case No. 255 specifically permits the omission of the flattening tests on the completed tube.

Case No. 312—Inquiry: Is it necessary in the construction of small Star-type water-tube boilers for steam heating which are to carry more than 15 lb. pressure at times, to drill the inside and outside ends of staybolts? It is believed that it was the intent of the committee to cover in this requirement the water legs at front and back ends which are considered as headers.

Reply: If the grate area is more than 15 sq.ft., the staybolts are less than 8 in. in length, and the pressure exceeds 15 lb., it will be necessary to drill the staybolts in order to comply with the Code requirements.

Installing Ammonia Shipping Cylinders

The Refrigerating Regulations Committee of the American Society of Refrigerating Engineers has sent the following notice to the builders, owners and operators of refrigerating equipment and members of the A. S. R. E.

The attention of this committee, which is drafting a code of regulations for the construction, installation, operation and inspection of refrigerating equipment, has been drawn to the fact that within recent months several explosions of anhydrous-ammonia shipping cylinders have occurred in establishments operating refrigerating equipment, which cylinders were said to have been emptied of their contents into the refrigerating system. One of these explosions resulted in the death of the engineer of the plant, and in another a laborer passing at the time of the explosion was seriously injured.

Careful investigations of these explosions have been made, and it appears that in each case the shipping cylinder was over-filled with ammonia from the plant, by the ammonia backing from the refrigerating system into the cylinders, leaving no gas space to take care of the expansion of the liquid ammonia with a rise in temperature, when the valve of the cylinder was closed. An explosion naturally had to occur.

The committee considers it of great importance that ammonia shipping cylinders should be connected to the refrigerating system in such a way that it will be impossible for anhydrous ammonia to back from the high-pressure side of the system into the cylinders. The Refrigeration Code, which will shortly be completed by this committee, contains a section which, if followed, will prevent such accidents. The section as now drafted reads as follows:

"Every refrigerating equipment shall be charged only through a connection located near the expansion valve on the *low-pressure side.*

"No shipping cylinder shall be connected to the refrigerating equipment except during the operation of charging."

This committee urges the builders of refrigerating machinery, consulting refrigerating engineers, owners and operators of refrigerating machinery, to adopt this regulation in the installation of new plants, and most respectfully requests that existing installations should be changed to meet this suggestion, in order that explosions and accidents of this kind may be prevented.

Fuel-Economy Symposium at Exposition of Chemical Industries

Included in the Sixth National Exposition of Chemical Industries held in the Grand Central Palace, New York, during the week ending Sept. 15, was a fuel economy conference. This is the first time in the history of chemical expositions that a section was devoted to fuel economy and an afternoon was given over to the reading of papers on this subject. Brief abstracts of the papers follow:

Burning Coal at 100 Per Cent B.t.u. Efficiency

W. O. Rankin

In this paper stress was placed on the economy of powdered coal due to the fact that when burning coal in the powdered form, the excess air necessary in ordinary coal to produce the flame conditions suited to particular requirements, can be eliminated, as the powdered coal is fed into the furnaces in a cloud where each particle quickly secures the air needed for combustion. The amount of excess air is always under control thus securing the greatest B.t.u. efficiency.

Saving Fuel by Controlling Chimney Losses

F. F. Uehling

Increased prices of fuel and difficulty in getting it at any price are two of the fundamental reasons why the subject of fuel economy is receiving more attention than ever before. No matter how fuel is consumed and no matter what kind of fuel is burned, whether solid, powdered, liquid or gaseous, the biggest loss is always due to the heat energy wasted up the chimney. Bulletin No. 205 issued by the Bureau of Mines says that "In the average boiler plant, 35 per cent of the heat in the coal burned under the boilers is lost with the stack gases. That is, out of every 100 tons of coal burned under the boilers, the heat of 35 tons literally goes up the stack." The loss up the chimney depends upon three factors; namely, excess air in the products of combustion, temperature of the products of combustion, and the amount of unconsumed fuel in the products of combustion.

Every kind of fuel requires a definite amount of air to burn it, depending principally upon the ratios of its carbon and hydrogen. Coal, the principal constituent of which is carbon, requires 12 pounds of air to completely consume each pound. All air that is used above that amount is excess air and places an unnecessary burden on the temperature possibilities of the furnace, and the amount of fuel consumed to obtain a required result increases in proportion to the amount of excess air used. In good practice 25 tons of air are used to burn one ton of coal. In poorly operated plants, this is sometimes doubled.

The exact amount of heat wasted by allowing the excess-air evil can be determined by the weight of the products of combustion per pound of fuel burned, and the temperature at which they leave the furnace or enter the stack. To reduce chimney losses to a minimum we must know whether or not the proper amount of air is being supplied, whether the air has been properly mixed with the fuel before it was ignited and whether too much heat is left in the products of combustion as they pass up the chimney. This can be determined with the assistance of fuel gas analyses and temperature measurements.

Fluid Heat Transmission

Alexander B. McKechnie

Heat transmission by hot oil embodies the desirable features and eliminates the objections of other methods for obtaining high temperatures. The quantity of heat delivered is under control at all times and temperatures are produced up to 550 degrees Fahrenheit without difficulty. This system is particularly adaptable to vessels with cast integral jackets usually built to withstand pressures of about 100 pounds. This point is readily understood when it is considered that 100 pounds of steam represents only 338 deg. F. The temperature can be controlled within close limits either manually or by thermostatic devices. The fire hazard is entirely removed as there is no flame in contact with the vessels and the absorber furnace, the only place where the flame exists, is isolated from the manufacturing equipment and sometimes it is even placed in a separate building. Experience has taught the superiority of the closed system. By a closed system is meant one in which the hot oil does not come in contact with the atmosphere. If it were allowed to do so it would rapidly oxidize and soon become too viscous to flow freely. Provision must be made for expansion of the oil as the circulating oils generally used have a coefficient of expansion of about .000486, which means about a 25 per cent volumetric increase in 500 deg. F. rise. An expansion tank is placed at the end of a stagnant line at the proper point in the system, which takes care of this point very satisfactorily.

Reducing Conduction and Radiation Heat Loss

S. L. Barnes

This paper brings out the fact that during the past few years the rapidly increasing prices and the scarcity of fuels of all kinds have focussed the attention of engineers upon the necessity for utilizing as much of the heat generated in high temperature equipment as possible. As a result of investigations it has been discovered that it is impossible to eliminate entirely the passage of heat through walls, arches, bottoms, doors, etc. It has been demonstrated that the reduction of heat radiation results in important advantages, such as increasing the capacity of the equipment with no increase in fuel consumption; making temperatures more constant and uniform throughout the apparatus; decreasing the time required to bring equipment to working temperature; lengthening the life of the refractories by eliminating the necessity for overheating in the combustion zone and providing much more comfortable working conditions for operating by reducing temperatures around furnaces. Mr. Barnes then explained that the company which he represents has experimented with a brick composed principally of earth which is practically pure silica. It is claimed that only one-tenth of the heat transmitted through a given thickness of ordinary brick would pass through the same thickness of this brick. Tests to determine the shrinkage and melting points made by Professor Edward Orton, of the Ohio State University, and those conducted by the Bureau of Standards, Washington, show that the insulating brick will withstand temperatures up to 1,650 deg. F. This heat resistance is ample if the bricks are properly installed and protected with sufficient refractory material.

Refractory Cement—Life Insurance for a Furnace

F. W. Reisman

This paper touched briefly the high spots of the uses for varied types of metallurgical and other furnaces where plastic high-temperature cement now replaces the use of fireclay. A number of stereopticon views illustrating the lecture were shown.

Reducing Fuel Consumption

Wm. R. Van Nortwick

Many plants are wasting money through lack of attention to the continually decreasing conductivity of the boiler. The ideal design of a steam generator would be one in which the fire would come in direct contact with the water with no wall or metal between. The very operation of the boiler tends to transmit the heat units from the fire to the water with a constant decrease in efficiency and increase in fuel consumption to accomplish a given result. This is due to the soot deposited on the tubes and the scale deposited in the boiler from the water.

Materials which are in suspension may often be filtered out. Such material of this character as passes into the boiler may to a great extent be removed by the surface blowoff. Where the principal scale-forming material is bicarbonite of lime, magnesium or iron, beneficial results may be obtained by means of the application of heat to a temperature of 212 deg. for periods of sufficient length to drive off the carbon dioxide, leaving a mono-carbonate, which is insoluble in water and which is therefore precipitated and removed from the feed water. Most waters contain material other than the carbonates, so that this treatment only partially removes the trouble, allowing the harder sulphates to be introduced into the boiler.

Oil Consumption of Turbo-Generator Sets

The amount of oil used by turbo-generator sets varies greatly, according to the size of the unit, the attention given it, whether there are any leaks in the system, etc. The accompanying chart enables one to find the number of barrels of oil used per year on direct-connected turbo-generator sets. In making this calculation 108 machines were used. The chart while, of course, representing an average, gives an idea of the estimated yearly consumption of a new machine.

In regard to using the chart, take, for example, a 4,000-kw. unit operating 120 hours per week. Following along the horizontal line to the number 4 and then up to where this vertical line cuts the incline marked 120, and following this intersection to the left, it will be found that such

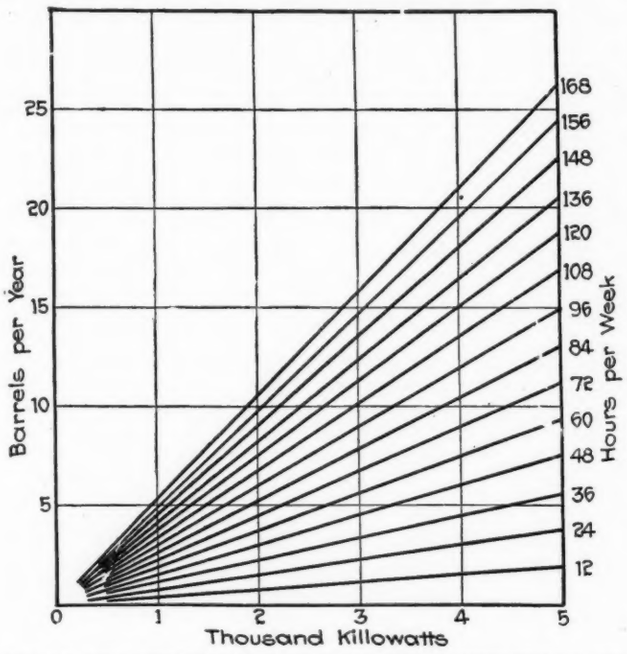


CHART FOR ESTIMATING ANNUAL OIL CONSUMPTION OF TURBO-GENERATOR SETS

a machine should use fifteen barrels of oil a year. This result may be checked by calculating on the assumption of 0.3 of a gallon per ten thousand kilowatt-hours. The rated kilowatt hours per week are 4,000 × 120 = 480,000. The oil used per week is, therefore, 48 × 0.3 = 14.4 gal., and the oil used per year is 14.4 × 52 = 748.8 gal., or practically 15 barrals as given by the chart—*The Atlantic Lubricator.*

Rules and Suggestions for Firemen and Boiler-Room Helpers*

For Firemen

Upon coming on watch, immediately observe steam pressure, water level in boilers and general conditions. Blow down water from water column to be sure it is working properly.

All coal and ashes are to be weighed and the time of coal loadings to be entered upon report sheet, the back weighing to be made at end of each shift and the back weight to be charged to the fireman coming on duty.

After boilers have been cleaned and in service four days, they are to be blown down once each day thereafter at about 8 or 9 o'clock in the morning. The engineer on watch is to be called at this time, and the extent and method of blowing down is subject to his approval.

Flues to be blown twice each day, on the first and second shifts, as soon as convenient after coming on duty.

Any defect in any boiler, steam pipe, feed pump or any apparatus in the boiler room should be reported at once to the engineer on watch.

In the event of heavy call for steam, such as a large fire and the fireman thinks he cannot hold steam with the boilers in use, he should report to the engineer at once.

Although it is not intended to lay down any hard and fast rule for firing, nor to discourage individual method if such method can be shown to be better than these, yet it is thought that a very good method of procedure is as follows:

Keep grates fairly clean, and preferably so by the use of shaker grates (although it is known that with some coal and conditions of fire it may be necessary to clean with slice bar and hoe). Fire at rather frequent intervals, say 7 to 10 minutes; firing at long intervals, say 12 to 15 minutes, is not good practice and is not approved. Manage damper and quantity fired so that the fires will not burn down dead and leave air holes at the time of next firing. In general, the least damper opening and draft you can use will be found most economical. When the draft is so great that fire burns down in holes, then heat is lost simply by heating the air drawn in at such points and does no good whatever.

It is suggested that the fireman learn to notice the draft gage, just as he observes the steam gage. It will indicate the need of shaking grates, the presence of air holes in fire when they burn too low, etc.

It is recommended that the firing be done as rapidly as possibly consistent with the proper spreading of the coal, so that the doors will be open as short a time as practicable; also when about to clean by the slice and draw method, all tools that are to be used should be right at hand before beginning to clean, and put away after the cleaning is finished and the door shut.

Firemen will answer the emergency call bell by reporting at once to the engineer.

If a fire alarm catches you with dirty fires, it is probably best to shake grates or clean at once and to do so as quickly as possible, even if you cannot take time to make the cleaning as complete as usual.

It is requested that the firemen, so far as is consistent with their other duties, shall keep the fireroom, coal shed, etc., in a neat and tidy condition. This also applies to the toilet room; always leave it in at least as good condition as you find it.

Fireman will sign his name to the recording steam charts on space that he is on duty.

For Boiler-Room Helpers

Follow our usual practice as to washing and cleaning boilers. As a general thing about three weeks is a proper length of run. Wash out all scale and mud, then pick off all scale that can be gotten at, and wash out again. In the case of the Stirling, the tubes may be turbined each cleaning, or the turbining may be omitted if conditions justify it.

Inspect boiler carefully for defective tubes, tubes needing rolling, bags in shell, or any leaks at any point. Also note the presence or absence of oil or grease in boiler and report to chief engineer. The tubes of tubular boilers should be brushed with wire brush when these boilers are cleaned.

Boiler setting should be frequently inspected by the candle method for air leaks. Fill any cracks or defects with a mixture of asbestos and fireclay.

The condition of baffles should be noted when Stirling boiler is cleaned and repairs made as needed.

The non-return valves provide against return of steam to a boiler that is being cleaned. Follow present practice in seeing that all valves on the feed or blowoff lines that can communicate with any supply of steam or hot water are closed. Also, until some other method is provided, wire the wheels of such valves so that they cannot be opened.

If the cleaning work takes you into a boiler alone, you should always notify the engineer on watch or other responsible party of the fact, and of which boiler you are working in.

When a boiler is being cleaned, the fusible plug should be inspected and cleaned, both on the outside and inside; if it seems defective, it should be replaced by a new one.

*Abstracted from paper by Dow W. Gwinn, read at 39th Annual Convention of New England Water Works Association.

Annual Convention Smoke Prevention Association

On Tuesday morning, Oct 5, the Smoke Prevention Association will assemble in annual convention at the Hotel Sherman, Chicago. An excellent program has been arranged. The morning session will be devoted to registration and addresses of welcome. On Tuesday afternoon there will be papers on "Smoke Prevention in Stationary Plants," by Nathaniel B. Wales, combustion expert; "Some Essentials in Smoke Prevention," by L. R. Pyle, of the Locomotive Fire Box Co.; "Chimneys and Chimney Draft," by Thomas S. Clark, chief engineer of the Alphons Custodis Chimney Co. The evening entertainment will be a theater party.

On Wednesday morning there will be papers on "A Suggested Solution of the Municipal Smoke Problem," by Dr. E. Vernon Hill, chief sanitary inspector of the City of Chicago; "Modern Development of Powdered Coal Burning," by Henry Kreisenger, of the Bureau of Mines; "Powdered Coal Practice," by H. A. Savage, of the Combustion Engineering Corporation. In the afternoon papers on "Heating Boilers and Furnaces" and "Power-Plant Design and Ventilation," by Prof. A. C. Willard of the University of Illinois, and "Smoke and Some of Its Effects on Health," by Dr. W. A. Evans, will be followed by an inspection trip to the Municipal Pier.

Thursday will be railroad day; the papers are as follows: "Value of Brick Arches in Smoke Prevention," by J. T. Anthony of the American Arch Co.; "Homely Talk to Railroad Men on Smoke Prevention," by H. T. Bentley of the Chicago & Northwestern R.R.; "Organization and Teamwork," by Harry Cluer, superintendent of fuel economy, Chicago, Rock Island & Pacific R.R. At the afternoon session the papers are: "Smoke Prevention With Locomotive Stokers," by A. N. Willsie, of the Locomotive Stoker Co.; "The Railroad Situation," by Samuel O. Dunn, editor of *Railway Age;* "Railroad Smoke Prevention," by D. R. MacBain, general fuel superintendent of the New York Central R.R. An automobile trip through the parks followed by dinner at the Marigold Gardens completes the program for the day.

On Friday morning there will be a business meeting and election of officers, followed by a sightseeing trip through the Stock Yards.

Magnetic Clutches on Synchronous Motors for Steel-Mill Drives*

In spite of the well-recognized benefits to be derived from the use of synchronous motors, they have not been widely used in steel mills on account of their poor starting characteristics under load and the strong prejudice on the part of the operators against the use of auxiliary clutches to allow the motor to be started without load. This prejudice, as directed against the mechanical clutch, has been justified by many sad experiences, the reliability being low and the maintenance high. Furthermore, even were the mechanical clutch satisfactory from an operating point of view, it is not adapted for remote or automatic control, and therefore would practically limit the use of the motor to continuous-driving applications.

The magnetic clutch, purely by reason of its name, "clutch," has fallen heir to the ill repute of the mechanical type, and for this reason it has not been widely accepted by steel men as the solution of the problem. It is not, however, subject to the maladies of the mechanical clutch, nor does it share the latter's limitations as regards control. In such cases as it has been used, it has proved eminently satisfactory and has made the use of synchronous motors thoroughly practicable.

Synchronous motors with magnetic clutches have been thoroughly proved out for several years in units up to 600 hp. in the rubber industry for driving mixing rolls and in the cement industry for driving tube mills. This service is quite comparable to steel-mill service.

The combination has also been successfully applied to the driving of pumping machinery where the motor runs continuously and the pump is automatically started and stopped by means of a switch in the clutch circuit operated by a float or by the accumulator weights, according to the nature of the operation. In the case of accumulator service the added advantage of this arrangement is that it entirely eliminates the unloading device, which is the source of more or less trouble. For this reason alone the clutch has frequently been used in such service in connection with ordinary squirrel-cage motors.

The magnetic clutch has the characteristic that its torque builds up gradually, requiring from one to three seconds to attain its maximum value, according to the size. This insures an easy engagement without shock or tendency to pull the motor out of step. The maximum torque is a fixed quantity which cannot be increased by any adjustment within control of the operator, so that the action is always the same and the cheapest class of labor can operate safely.

The only adjustment is for lining wear, and this cannot be improperly done. When the lining is worn out, it can be replaced in fifteen minutes without in any way dismantling the clutch or shafts, so that delay to operation from this cause is not to be feared.

The clutch requires direct current for its operation. This can be taken from the exciter of the synchronous motor. The amount of current required will not exceed 750 watts for the largest unit that would ever be required by this service.

In addition to its primary purpose of loading the motor, the clutch often serves as a safety device, making it possible to cut off the motor and thus eliminating the high inertia parts so that a quick stop may be obtained in case of emergency. This is of particular value in driving roll stands.

*Electrical-Development Committee Report, presented at the fourteenth annual convention, Association of Iron and Steel Electrical Engineers, New York City, Sept. 20-24.

Large Sum for Industrial Research

Great problems of industrial research are to be worked out at New York University with the co-operation and financial support of leading American universities.

In the new Engineering School buildings of the University, the erection of which is made possible by the $500,000 donation of the late Mrs. Russell Sage, the large corporations of the country are endowing research fellowships. The names of many large corporations who, either with cash or its equivalent in equipment, are to take part in this latest application of research to industry will shortly be made public.

This movement represents the alliance of industries in related fields for the purpose of carrying out research work in the technical laboratories of the University. Although some of the basic industries have their own laboratories for research and Government facilities are offered to others, it has been found that many experimental investigations can be carried out in the laboratories of such institutions as New York University.

The New School for Social Research, 465 West Twenty-third St., New York City, has established a course of study, conference and research on the Social Function of the Engineer, which will be given during the coming scholastic year, beginning Oct. 13. The course will comprise a series of Wednesday evening lectures and conferences covering the relations of the trained engineer to the present social order. Experienced engineers in various fields of endeavor will contribute to the lectures and conferences. O. S. Beyer, Jr., consulting engineer, formerly of the University of Illinois and a graduate of Stevens School of Technology, will administer this course. The tuition fee for the course has been fixed at twenty dollars.

The City Council of Wilmington, Del., has passed an ordinance providing for the examination and licensing of stationary engineers.

Society Affairs

The Executive Committee of the American Welding Society (New York) has recommended that a New York Section be formed to operate separately from the parent organization.

The American Association of Engineers has opened offices in Boston at 50 Broomfield St., Room 305. Fred C. Lewis is temporary managing secretary and also recording secretary.

The California State Assembly of A. A. E. is assisting J. C. Whitman, chief examiner of California Civil Service Commission, in making a preliminary classification of engineering service in that state. Members of the assembly are obtaining comment on the tentative classification from various corporations and individuals throughout the state.

The American Electric Railway Association will hold its thirty-ninth annual convention in Atlantic City, Oct. 11-15. Eugene McAuliffe, president of the Union Colliery Co., of St. Louis, and formerly manager of the Fuel Conservation Section of the United States Railroad Administration, will speak on "Problems of Fuel Supply."

Baltimore Chapter, A. A. E., on Sept. 17 held a mass meeting attended by 350 leading Baltimore engineers. Mayor Broening, chief engineer, Henry Perrin, chairman, John Greiner of the Port Development Committee, and others told how the engineers could assist in inducing the citizens of Baltimore to adopt a bond issue for improving the harbor and other public works of Baltimore.

The Committee on Ethics and Compensation of the San Francisco Chapter of A. A. E. recently adopted a resolution calling for increases in Federal engineering salaries to the following: Junior engineer, minimum $1,800, maximum $2,700; assistant engineer, minimum $2,700, maximum $4,000; senior assistant engineer, minimum $4,000, maximum $5,000; engineer, minimum $5,000, maximum $7,500.

Charleston Chapter, A. A. E., has protested to the Secretary of the Navy regarding the recent salary awards which resulted in a net decrease in salaries of some of the technical employees in the Navy. The communication requests a reconsideration of the case. The award was a 5 per cent flat increase, but the establishment of half holidays without pay except during the summer months resulted in a net decrease in salary of 1¼ per cent.

The Waterbury Section, A. S. M. E., will hold the first meeting of the season Saturday, Oct. 2, at Stevenson, Conn., where, at the invitation of Irvin W. Day, vice president of the Connecticut Light and Power Co., the members will inspect the company's new hydro-electric plant at Stevenson on the Housatonic River about eight miles above Derby. The trip to Stevenson will be made by automobile, leaving the Waterbury Club at 12:45 p.m. Members of other engineering societies are cordially invited to participate in this trip.

The Empire State Gas and Electric Association will hold its Sixteenth Annual Convention at the Hotel Utica, Utica, N. Y., Oct. 7 and 8. The following papers will be read: "Selling in a Small Community," H. K. Stein, superintendent, Genesee Light and Power Co.; "Importance of Meter Testing," F. J. Murmann, superintendent of meters, Westchester Lighting Co.; "Service Charge Rate," A. Parshall, consulting engineer; "Financing Utility Properties," R. M. Searle, president, Rochester Gas and Electric Corp.; "Consumers' Viewpoint," G. I. Vincent, engineer, Syracuse Lighting Co.; "Coal Situation," G. N. Snider, coal traffic manager, New York Central R.R. The entertainment committee has arranged a dinner, golf tournament and an automobile trip to Trenton Falls.

The Cleveland District Section of the Association of Iron and Steel Electrical Engineers' program for 1920-21 includes the following: Meetings — Oct. 11; paper, "Trouble of the Electrical Operating Man." by A. W. Mohrman, assistant electrical superintendent, Trumbull Steel Co., Warren, Ohio. Nov. 8; paper, "Slip Regulators vs. Notchbacks," by Gordon Gage, chief electrician, American Rolling Mill Co., Middletown, Ohio. Dec. 13; paper, "Continuous Rated or 50-Degree Rise Motors," by L. F. Adams, electrical engineer, power and mining department, General Electric Co., Schenectady, N. Y. Jan. 10, 1921; paper, "The Proper Selection of Carbon Brushes," by L. A. Heath, engineer, Morganite Brush Co., New York, and John S. Cavitt, Electrical Engineering and Manufacturing Co., Pittsburgh. Feb. 14; paper, "Scientific Combustion Control for Boiler Furnaces," by M. G. Benjamin, Benjamin Engineering Co., Cleveland. March 14; paper, "Electric Propulsion Ships," by W. E. Thaw, Westinghouse Electric and Manufacturing Co., Pittsburgh. April 11; paper, "Electrical Clearing of Gases as Applied to Blast Furnaces," by N. H. Gellert, president, Gellert Engineering Co., Philadelphia. May, inspection trip, to be outlined later. June, the annual outing.

Miscellaneous News

A Fifteen-Year Program, involving the expenditure of $200,000,000 in the development of 750,000 horsepower of electric energy from the water of the Kern and San Joaquin Rivers, Big Creek and Huntington, Sjaver and Florence Lakes, was announced recently by the Southern California Edison Company.

The Southern California Edison Co. has asked the Railroad Commission for authority to sell its electrical distribution line on the Base Line Road, San Bernardino County, to the Ontario Power Co. The price is given as $12,500. The Ontario company serves the cities of Ontario and Uplands and contiguous territory. It is said transfer of the distribution line will render unnecessary the building of another line by the Ontario company and that the transfer of ownership can be accomplished without injury to the public.

Capitalists of San Antonio, Tex., interested in the Syndicate Power Co., organized heretofore with a capitalization of $20,000,000, are endeavoring to complete arrangements to finance their enterprise this year and begin actual construction during the winter on hydro-electric plants that will generate a total of 48,000 kw. One dam is partially under construction, and there are four other dam sites available on the Colorado River at and near Marble Falls, Tex., where the first hydro-electric installation will be placed. Engineers have estimated the cost of the plants now in view at $12,000,000.

Business Items

The American Steam Conveyor Corporation announces the change in its corporate name to the "Conveyors Corporation of America." There is no change either in the personnel or policy of the company.

The R. H. Beaumont Co., 319 Arch St., Philadelphia, contractor for conveying and hoisting systems and complete power plants, has opened an office at 230 Fifth Ave., Pittsburgh, Pa. Thomas Widdop is in charge.

Trade Catalogs

"B-G Standardized Material Handling Machines" is the title of a new 32-page catalog now ready for distribution by the Barber Greene Co., Aurora, Ill. Self-feeding bucket loaders, portable belt conveyors and permanent belt conveyors handled by this company are described and illustrated by photographs in the catalog, a copy of which will be sent to anyone interested on request.

The Reading Iron Co., of Reading, Pa., has ready for distribution a new 31-page catalog entitled "Reading Wrought Iron Pipes." A brief history of the iron industry since the time the metal was first discovered until the present time is contained in the booklet. This is followed by a description, accompanied by illustrations, of the modern processes as carried out by the Reading Iron Co. A copy will be sent on request.

The Story of Gasoline is the title of a new 38-page booklet now ready for distribution by the Atlantic Refining Co. The book contains an account of various stages necessary for refining gasoline. Illustrations are given of the equipment used by the company for refining this product. A description of the proper method of using gasoline in an automobile engine, adjustment of carburetor, etc., is given. The booklet closes with a diagnosis of various sorts of engine trouble and remedies.

The Engineer Co., 17 Battery Place, New York City, has just received from the printer a new 30-page catalog entitled "Modern Practice in Combustion Control," which should prove of interest to engineers, particularly those interested in the subject of combustion. A brief history of the science of combustion is given and also a description of the principles, apparatus and operation of balanced draft. Photographs and line drawings illustrate the text.

New Construction

PROPOSED WORK

Mass., Boston—The Lighthouse Supt. will receive bids until October 15 for installing new boiler on Light Vessel No. 47.

Mass., New Bedford—The Bd. Educ. will receive bids until October 13 for a 2 story, 170 x 250 ft. school on Rochambeau St. and a 2 story, 153 x 270 ft. school on Mt. Pleasant St. Steam heating systems will be installed in same. LaBrode & Bullard, 255 Union St., Archts.

Mass., Wakefield—Lee & Hewitt, Archts., 1123 B'way, New York City, will soon award the contract for a 1 story, 40 x 50 ft. boiler house here for the Heywood Bros. and Wakefild Co., Gardner.

Conn., Glenville—The United States Finishing Co., Greenville, will soon award the contract for a 1 story, 40 x 110 ft. boiler plant. Day & Zimmerman, 611 Chestnut St., Philadelphia, Pa., Archts.

N. Y., Brooklyn—The Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until October 6 for an underground electric light and power distrbiuting system.

N. Y., Marcy—The State Hospital Commission, Capitol, Albany, will soon award the contract for the installation of a heating system and generator set in the Utica State Hospital here. Noted Sept. 28.

N. Y., Rome—The Rome Wire Co. is having plans prepared for a 560 hp. heating plant including 2 Heine horizontal water tube boilers with Wetzel mechanical stokers, American Steam Corp.'s ash conveyor, Link Belt Co. coal handling equipment, pumps, and feed water heaters, etc. R. M. Fraser, Asst. Mgr.

N. J., Asbury Park—Lester R. Weller & Son., 21 Corlies Ave., received bid for a 1 story ice plant, garage and office from the American Federal Masonry Co. at $20,000.

N. J., Glassboro—The State, Trenton, received bids for a 41 x 49 ft. power plant including 4 boilers from the Standard Constr. Co., 1713 Sansome St., Philadelphia, $20,000; G. Dose, 43 West 27th St., New York City, $28,000.

Pa., Harrisburg — The City, Commonwealth Bldg., has retained James H. Fuertes, Consult. Engr., 140 Nassau St., New York City, to prepare plans for a pump station including engines, etc. About $273,000.

Md., Annapolis—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install boiler plant equipment and piping.

Md., Baltimore—The Bd. of Awards received bids for furnishing and installing feed pumps, renewing tubes in boilers and installing additional tubes in the power house at the Bayview Hospital, from H. A. Kries & Sons Co., 6 Lombard St., $15,279.

D. C., Washington—The Sacred Heart Church, c/o F. V. Murphy, Archt., 1413 H St., will soon award the contract for a 1 story church including a steam heating system on 15th St. and Park Place. About $1,000,000.

N. C., Ashville — The J. G. Stikeleather Syndicate, c/o Herts & Robertson, Archts., 331 Madison Ave., New York City, plans to build a hotel including a steam heating system. About $1,500,000.

Ala., Birmingham—The Corona Coal Co. plans to install a 200 kva. rotary converter and a 100 hp. hoist. L. M. Adler, Genl. Mgr.

Tenn., Memphis—The Memphis Hotel Co. plans to construct a hotel including a steam heating system. About $2,500,000. G. S. Parker, Mgr. W. L. Stoddart, 9 East 40th St., New York City, Archt. and Engr.

O., Cleveland—The Central Y. M. C. A., c/o C. V. Thomas, Secy., East 22d St. and Prospect Ave., plans to build an 8 story Y. M. C. A. addition including a steam heating system. About $1,000,000. Hubbell & Benes, 4500 Euclid Ave., Archts.

O., Cleveland—The City, c/o E. H. Long, Archt., City Hall, is in the market for one 50-hp. motor and seven motors of 4 to 8 hp. each.

O., Cleveland—The Crowell & Little Co., 1951 East 57th St., plans to build a 10 story, 150 x 170 ft. commercial and office building including a steam heating system, on East 13th St. and Chester Ave. About $1,250,000.

O., Cleveland—S. Gurss, 1261 East 99th St., plans to build a 1 story theatre including a steam heating system on Euclid Ave. east of 79th St. About $250,000.

O., Cleveland—St. Hyacinth's Church, c/o Rev. Redmer, East 61st St. and Francis Ave., is having plans prepared for a 1 story, 40 x 80 ft. boiler house. One 200-hp. boiler will be installed in same. About $25,000. W. C. Jansen, Electric Bldg., Archt.

O., Cleveland—Bd. Educ., c/o L. W. Jones, Pres., Chagrin Falls, plans to build a 2 story school including a steam heating system in Orange Township. About $300,000.

O., Ravenna—The Warren Hotel Co., c/o P. E. Robinson, 537 Guardian Bldg., Cleveland, plans to build an 8 story, 75 x 100 ft. hotel here, including a steam heating system. About $400,000. Moulthrop & Nichols, 5716 Euclid Ave., Cleveland. Archts.

Ill., Chicago—Philipsborns, 511 South Paulina St., is having plans prepared for a 7 story, 126 x 170 ft. addition to mail order house including a steam heating system on Harrison and Paulina Sts. About $1,300,000. A. S. Alschuler, 28 East Jackson St., Archt.

Ill., Chicago—The Republic Life Insurance Co., 108 South La Salle St., is having plans prepared for a 6 story, 75 x 130 ft. office building including a steam heating system on Washington and Sheldon Sts. About $250,000.

Wis., Racine—The Bd. Educ. is having plans prepared for a 3 story addition to the Washington School including an intermediate high school and a power house. About $340,000. E. B. Funston Co., Robinson Block, Archt.

Iowa, Clinton—The Clinton Gas & Electric Co. plans to install additional turbines to develop 3,500 kw. power.

Minn., Minneapolis—The Bd. Educ., c/o G. F. Womrath, Supt., City Hall, received bids for installing a steam heating and ventilating system in the Clinton School addition, from Bjorkman Bros., 712 South 10th St., $41,399; Conner Bros. Heating and Plumbing Co., 711 6th Ave., North, $42,819; Western Heating Co., 13 East 36th St., $43,148.

Minn., St. Paul—The city received bids for 1 vertical triplex motor driven pump of 350 gal. capacity per minute against a total 150 ft. head, single acting, belt for 150 lbs. pressure, from the Power Equipment Co., 212 North 3d Ave., Minneapolis, $2,910 (with extras, $3,078); Robinson, Cary & Sands Co., 4th and Waconta Sts., $2,510; Northwestern Electric Equipment Co., 176 East 6th St., $3,574.

Kan., Portis—J. E. Kissel, City Clk., plans to expend $30,000 for waterworks improvements including a 5-hp. electric motor, direct connecting unit, etc.

S. D., Mitchell—The city plans to install a steam heating system in the proposed 1 story, 182 x 300 ft. corn palace auditorium on North Main St. and 6th Ave.

N. D., Fargo—The Elks' Lodge, No. 260, plans to build a clubhouse including a steam heating system. About $250,000.

Tex., San Angelo—The San Angelo Water, Light and Power Co. plans to install additional equipment in its plant here.

Okla., Enid—The Enid Masonic Temple Association, 202½ North Main St., will receive bids until November 15 for a 4 story, 100 x 150 ft. temple. Contracts for the installation of heating and plumbing systems in same will be sublet. About $325,000. R. W. Shaw, Bech Bldg., Archt.

Okla., Eufaula—The Pioneer Electric & Power Co. is in the market for second-hand equipment for the manufacture of ice including ammonia tanks, piping, hoists, etc.

Okla., Oklahoma City—The Okahoma Terminal Elevator Co. plans to build a 62 x 150 ft. elevator building. Electric power will be installed in same. About $600,000. P. L. Jackson, Secy.

Col., Denver—The School Bd. received bids for the installation of a heating system in the proposed 2 story, 158 x 340 ft. Morey Junior High School on 14th Ave. and Emerson St., from McCarty-Johnson Heating Co., $89,031; and in the proposed 2 story, 125 x 350 ft. junior high school on South Washington and South Pearl Sts., from Johnson Davis Plumbing and Heating Co., $90,000. Noted August 10.

Utah, Provo—The Goshen Bay Irrigation Co. plans to install electrically operated pumping plants and drainage systems in connection with the proposed irrigation and drainage project.

Wash., Cedar Falls—The City Council of Seattle plans to build a 1 story, 44 x 64 ft. power house here to include the installation of generating unit and transformers. About $1,000,000. Daniel Huntington, Archt. Noted June 1.

N. B., Grand Falls—The New Brunswick Electric Power Commission plans to build a power plant here in addition to the power developments at Shogomoc and Musquash. C. O. Foss, St. John, Chief Engr.

Ont., Windsor—The School Bd. plans to build a 2 story, 180 x 200 ft. school including a steam heating and ventilating system. About $400,000. Mayor Winter, Chn.

CONTRACTS AWARDED

N. Y., New York—The Clinton Hall Association, 1375 Astor Pl., has awarded the contract for altering a 7 story store, library and office building including a steam heating system to Hegeman Harris, 185 Madison Ave., at $265,000.

Pa., Nanty Glo—The Lincoln Coal Co. has awarded the contract for furnishing 300 hp. electric current to the Pennsylvania Central Light & Power Co., Altoona.

Pa., Philadelphia—The Carver File Co., 3231 Frankford Ave., has awarded the contract for a 1 story, 27 x 48 ft. power house on Tacony and Buchius Sts to W. Steele & Sons Co., 16th and Arch Sts.

Pa., Philadelphia—The Cramp Shipbuilding Co., Richmond and Norris Sts., has awarded the contract for a 2 story, 60 x 120 ft. power hous addition to Fred A. Havens, 845 North 19th St.

Ala., Birmingham—Loew's Enterprises, 1492 Bway., New York City, will build a theater here, including a steam heating system. About $600,000. Work will be done by day labor.

O., Cleveland—The Cleveland Ry. Co., Leader-News Bldg., has awarded the contract for a 1 story, 46 x 72 ft. electric substation at East 152d St. and St. Clair Ave. to W. I. Thompson & Son Co., 5103 Euclid Ave. About $100,000. Noted April 20.

O., Cleveland—The Jacob Lamb Baking Co., 4919 Lorain Ave., has awarded the contract for a 1 story, 30 x 50 ft. boiler room, to the Lehder Constr. Co., Engineers' Bldg., at $25,000. Noted September 21.

O., Grafton—The City has awarded the contract for a pumping station to Dobson-Maines Co., Pittsburgh, Pa., and for two deep well pumps to the Cleveland Pump & Supply Co., Guardian Bldg., Cleveland. Noted Feb. 16.

O., Linden (Columbus P. O.)—The Bd. Educ., Tower and High Sts., has awarded the contract for the installation of heating, plumbing and ventilation systems, etc., in the proposed school here to S. A. Effwein & Co., West Broad St., at $45,552.

O., Springfield—The Bd. Educ. has awarded the contract for a 2 story, 110 x 128 ft. school including a steam heating system on Maiden Lane to Paul R. Yeazel, 2233 Columbus Ave., at $241,745.

Wis., Florence—The city has awarded the contract for furnishing 3 centrifugal motor driven pumps, from 100 to 500 gal. per minute capacity, 2 operating panels equipped with automatic controllers, meter and oil switches, 1 electric siren and 1 small air compressor, to the Allis-Chalmers Mfg. Co., West Allis St., at $4,810. Noted July 27.

Minn., Pipestone—The City has awarded the contract for a 1 story pumping station to Hunt & Sons, at $13,718. Noted July 7.

S. D., Sioux Falls—The Diocesan College has awarded the contract for the construction of a 2 story, 40 x 60 ft. service building and a 60 x 60 ft. (underground) heating and power plant to Carson & Smithkey, Sioux Falls, and for furnishing refrigeration and power equipment to the L. E. Pollard Co., 423 South 5th St., Minneapolis, Minn. Noted March 9.

Mo., St. Louis—The Gerst Bros. Meat Co., 3823 Lucky Ave., has awarded the contract for a 1 story, 35 x 50 ft. engine room at 3811-15 Lucky Ave. to Gillespie & Daly, International Life Bldg., at $12,000.

Tex., Austin—The State Bd. of Control has awarded the contract for installing a heating plant in the proposed hospital on West 6th St., to John L. Martin, 408 Congress Ave., at $46,490.

Ore., Portland—The Eastern & Western Lumber Co., foot of 21st St., North, will build a power plant. About $25,000. Work will be done by day labor.

Need Competent Help?

See Pages 96 to 112

Let the "SEARCHLIGHT" Help You

See Pages 96 to 112

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		85c. per ft.
Common, 2½-in.		30%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.60	$0.40	$0.30

Steam—Discounts from List

First grade. . 20% Second grade.....30% Third grade....45%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 50% Best grade..... 20%
Standard..... 30–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
30%	25%	20%

RAWHIDE LACING { For cut, best grade, 25%, 2nd grade, 30%. / For laces in sides, best, 79c per sq. ft.; 2nd, 75c. / Semi-tanned: cut, 20%; sides, 83c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	1.70
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.50
Rubber sheet	.50
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... List +5%

For low-pressure heating and return lines { 4-ply ..... 50% off / 3-ply ..... 52% off / 2-ply ..... 54% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Chicago	St. Louis	Birmingham	Denver
Cup	8½	6.6	8@ 9	8½	13½
Fiber or sponge	8½	8.6	12@15	8½	20
Transmission	10	8.1	12@15	8½	20
Axle	...	4.8	6@ 6½	5½	7½
Gear	6½	6.1	8@9	5½	8½
Car journal	12(gal.)	4 7	23@25	8½	8½

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
White	15.00@17.00	13.00	16.00	11.00 to 14.00
Colored mixed	9.00@14.00	9.00 to 12.00	12.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Chicago	
	Current	One Year Ago	Current	One Year Ago
Raw in barrels (5 bbl. lots)	$1.25	$2.25	$1.22	$2.37
5-gal. cans	1.40	2.40	1.47	2.57

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	15.50	17.00	13.00	14.50	15.50	13.00
25- and 50-lb. kegs	15.75	17.25	13.25	14.75	15.75	13.25
12½-lb. keg	16.00	17.50	13.50	15.00	16.00	13.50
1-lb. cans	18.50	20.00	15.00	16.50	15.00	15.00
5-lb. cans	20.50	22.00	16.00	17.50	16.00	16.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	List net	40%	30%
Tinned	List net	40%	30%

Boiler rivets, ½, ⅝, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$6.00 Chicago.....$5.62 Pittsburgh.....$4.50

Structual rivets, same sizes:

New York.....$7.10 Chicago.....$5.72 Pittsburgh.....$4.60

REFRACTORIES—Prices in carlots:

Bauxite brick, 56% alumina, f.o.b. Pittsburgh	per 1000	$160
Chrome brick, eastern Shipping points	net ton	100@$110
Chrome cement, 40@45% Cr_2O_3	net ton	55@ 60
Chrome cement, 40@45% Cr_2O_3 in sacks	net ton	60@ 65
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	110
Magnesite brick: 9-in. arches, wedges and keys	net ton	121
Magnesite brick: Soaps and splits	net ton	134
Silica brick: Chicago district	per 1000	65@ 70
Silica brick: Birmingham, Ala	per 1000	56@ 61
Silica brick: Mt. Union, Pa	per 1000	55@ 60

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	90.00	90.00	57.00	79.00	60.00	60.00
Commercial	50.00	50.50	21.00	17.50	15.00	13.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$20.00	25.50–30.00
Cleveland	20.00	20.00
Chicago	21.00	16.50

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 12c. per lb.

SHEETS—Quotations are in cents per pound in various cities from warehoues also the base quotations from mill:

Blue Annealed	Large Mill Lots Pittsburgh	St. Louis	Chicago	San Francisco	New York—Current	New York—One Yr. Ago
No. 10	$3.55@$7.50	$7.09	$7.02	$8.65	$7.23@$8.00	$4.57
No. 12	3.60@ 7.55	7.09	7.07	8.70	7.28@ 8.05	4.62
No. 14	3.65@ 7.60	7.09	7.12	8.75	7.33@ 8.10	4.67
No. 16	3.75@ 7.70	7.09	7.17	8.85	7.43@ 8.20	4.77
Black						
*Nos. 18 and 20	4.15@ 8.30	8.10	7.80	10.60	8.41@ 9.80	5.30
*Nos. 22 and 24	4.20@ 8.35	8.10	7.85	10.65	8.46@ 9.85	5.35
*No. 26	4.25@ 8.40	8.10	7.90	10.70	8.51@ 9.90	5.40
*No. 28	4.35@ 8.50	8.10	8.00	10.80	8.61@10.00	5.50
Galvanized						
No. 10	4.70@ 8.50	9.60	8.50	....	8.91@11.50	6.20
No. 12	4.80@ 8.60	9.60	8.60	11.35	9.01@11.50	6.25
No. 14	4.80@ 8.60	9.60	8.60	11.35	9.01@11.60	6.30
Nos. 18 and 20	5.10@ 8.90	9.60	8.90	11.65	9.26@11.90	6.60
Nos. 22 and 24	5.25@ 9.05	9.60	9.05	11.80	9.41@12.05	6.75
*No. 26	5.40@ 9.20	9.60	9.20	11.95	9.56@12.20	6.90
†No. 28	5.70@ 9.50	9.60	9.50	12.25	9.86@12.50	7.20

*For painted corrugated sheets add 30c. per 1000 lb. for 5 to 28 gage; 25c. for 19 to 24 gages; for galvanized corrugated sheets add 15c., all gages.

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card:

BUTT WELD

Steel			Iron		
Inches	Black	Galv.	Inches	Black	Galv.
⅛ to 3	45 to 57½	41½ to 44	⅛	15½ to 25½	+1½ to 11
			¼	19½ to 29½	1½ to 11½
			⅜ to 1½	24½ to 34½	8 to 18½

LAP WELD

2	47 to 50½	34½ to 38	2	20½ to 28½	6½ to 14½
2½ to 6	50 to 53½	37½ to 41	2½ to 6	22½ to 30½	9½ to 17½
7 to 12	47 to 50½	33½ to 37	7 to 12	19½ to 27½	6½ to 14½
13 and 14	37½ to 41				
15	35 to 38½				

BUTT WELD, EXTRA STRONG, PLAIN ENDS

⅛ to 1½	52 to 55½	39½ to 43	⅛ to 1½	24½ to 34½	9½ to 19½
2 to 3	53 to 56½	40½ to 44			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	45 to 48½	33½ to 37	2	21½ to 29½	8½ to 16½
2½ to 4	48 to 51½	36½ to 40	2½ to 4	23½ to 31½	11½ to 19½
4½ to 6	47 to 50½	35½ to 39	4½ to 6	22½ to 30½	10½ to 18
7 to 8	43 to 46½	29½ to 33	7 to 8	14½ to 22½	2½ to 10½
9 to 12	38 to 41½	24½ to 28	9 to 12	9½ to 17½	5½ to+2½

BOILER TUBES—The following are the prices for carload lots, f.o.b. Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	15 to 40½	1¾ and 1½ in.	+20
2½ to 3¼ in.	10 to 30½	2 and 2¼ in.	+10
2½ in.	4 to 24	2½ and 2¾ in.	+1
1¾ to 2 in.	+½ to—19½	3 and 3½ in.	—1½
		3¾, 4 and 4½ in.	—8

Standard Commercial Seamless — Cold Drawn or Hot Rolled

Per Net Ton		Per Net Ton	
1 in.	$327	1¾ in.	$207
1¼ in.	267	2 to 2½ in.	177
2½ in.	257	2¾ to 3½ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 95.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	+ 5%
Coils to 1,000 ft.	— 5%
1,000 ft. and over	—10%

List Net
+15%
7%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.48
12 to 50	.41
50 to 125 (bbl.)	.38
125 (bbl.) or over	.35

CONDUIT, ELBOWS AND COUPLINGS—These prices are in 100-lb. lots, f. o. b. New York, with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
⅜	85.00	93.50	22.00	524.60	6.65	7.30
½	11.50	126.50	29.00	32.00	11.25	12.37
¾	170.00	187.00	41.00	45.00	15.50	17.00
1	230.00	253.00	52.00	57.00	20.70	23.60
1¼	275.00	302.50	70.05	78.00	25.00	27.50
1½	375.00	403.00	130.00	145.09	33.70	37.00
2	585.00	613.80	210.00	235.00	47.50	53.00
2½	765.00	841.50	560.00	620.00	70.00	78.00
3	920.00	1,012.00	1,350.00	1,485.00	92.00	114.00
3½	1,170.00	1,287.00	1,469.00	1,617.00	115.00	140.00
4						

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
⅝	250	.09
¾	200	.12
⅞	200	.15
1	150	.18
1¼	100	.25
1½	100	.33
1¾	Odd lengths	.40
2	Odd lengths	.55

1000 ft. and over..... 40% off
Coils..... 30% off
Less coils, 20% off

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.43
D. P. M. L.	.21	T. P. to D. P. S. B.	.26
T. P. M. L.	.33	T. P. S. B.	.38
D. P. S. B.	.23	T. P. D. B.	.64

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.50	$1.30	$1.68
T. P. M. L.	.70	1.70	2.40
D. P. S. B.	.63	1.60	.....
T. P. S. B.	1.15	2.40	.....
D. P. D. B.	1.10	3.00	.....
T. P. D. B.	1.90	5.40	.....
T. P. to D. P. D. B.	1.30	3.80	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$25.00
No. 16 cotton twisted	29.00
No. 18 cotton parallel	32.00
No. 16 cotton parallel	39.50
No. 18 cotton reinforced heavy	43.00
No. 16 cotton reinforced heavy	50.00
No. 18 cotton reinforced light	37.50
No. 16 cotton reinforced light	43.00
No. 18 cotton Canvasite cord	30.00
No. 16 cotton Canvasite cord	33.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
425-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package 15%
1-5th to standard package 28%
Standard package 45%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package	$5.25C
0–30 ampere, less than standard package	6.00C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs — Mazda B—				Pear-Shaped Bulbs — Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.28
Composition 2-piece attachment plug	.36
Swivel attachment plug	.20
Current taps	.45

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$11.50	$14.25	$17.00	$28.50
12	14.96	18.50	21.45	35.00
10	20.62	24.75	28.05	46.00
8	28.90	33.30	38.50	66.00
6	.....	.....	58.75	.....
4	.....	.....	80.75	.....
2	.....	.....	111.00	.....
1	.....	.....	154.00	.....
0	.....	.....	181.50	.....
00	.....	.....	220.00	.....
000	.....	.....	265.00	.....
0000	.....	.....	330.00	.....

Prices per 1000 ft. for Rubber-Covered Wire in Following Cities:

	Denver			Birmingham			St. Louis		
	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$15.64	.....	$38.45	$12.23	.....	$38.64	$15.64	.....	$38.45
10	24.50	.....	.....	27.60	.....	65.57	24.50	.....	58.70
8	33.48	$56.81	.....	38.64	.....	87.33	33.48	.....	.....
6	.....	77.17	.....	69.12	.....	.....	.....	56.81	.....
4	.....	108.10	.....	.....	$107.42	.....	.....	77.17	.....
2	.....	142.00	.....	.....	138.46	.....	.....	108.10	.....
1	.....	167.70	.....	.....	178.52	.....	.....	142.00	.....
0	.....	198.20	.....	.....	217.09	.....	.....	167.70	.....
00	.....	234.60	.....	.....	263.57	.....	.....	198.20	.....
000	.....	279.60	.....	.....	320.44	.....	.....	234.60	.....
0000	.....	.....	.....	.....	389.17	.....	.....	279.60	.....

Pittsburg—23c. base; discount 50%. St. Louis—30c. base.

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap			¾ In. Cap		
Key Each	Keyless Each	Pull Each	Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package +50%
1-5th to standard package +20%
Standard package —10%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	55c. lb
No. 18 B. & S. regular 1-lb. coils	56c. lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 56c. lb., 100 lb. lots	52c. lb
Rubber tape, ¾ in., less 100 lb. 65c. lb., 100 lb. lots	60c. lb
Wire solder, less 100 lb. 47c. lb., 100 lb. lots	42c. lb
Soldering paste, 2 oz. cans	$1.50 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.75	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	+25%
$10 to $25 list value	+10%
$25 to $50 list value	+ 5%
$50 to $200 list value	—10%
$200 list value or over	—15%